The
ENGINEERS' DIGEST

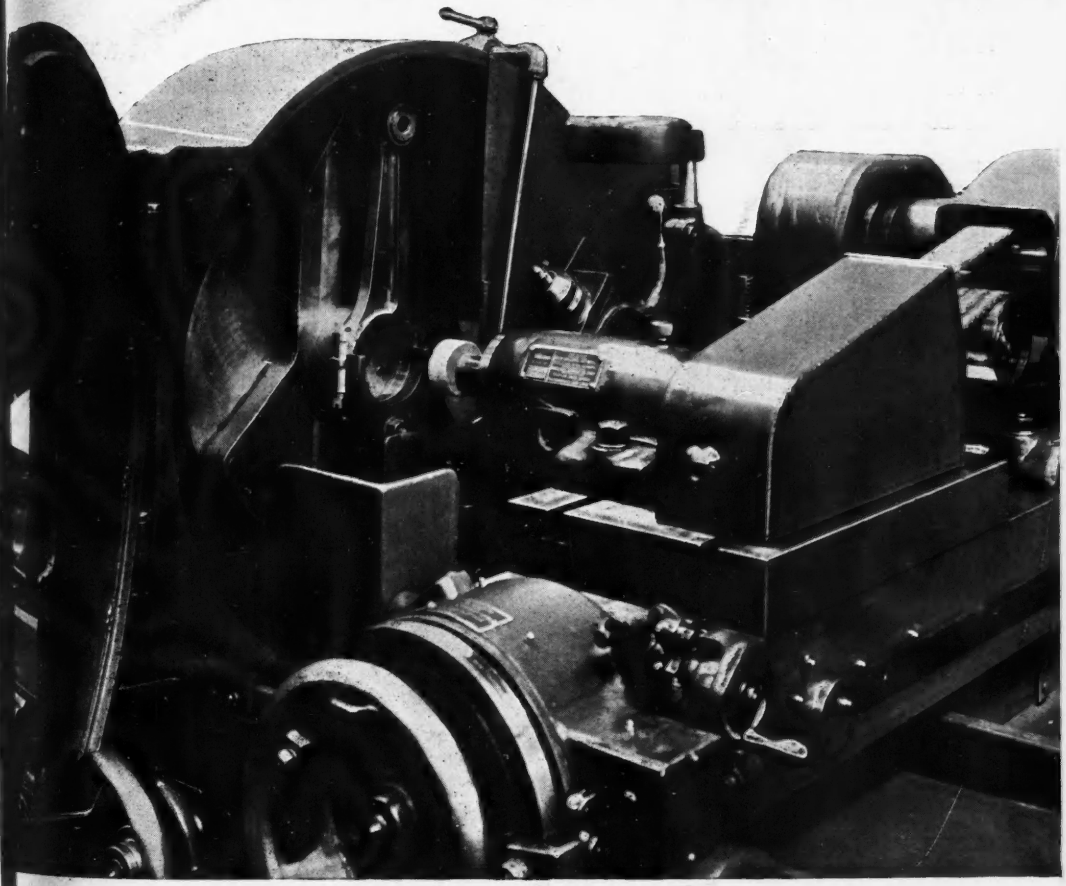
REVIEW OF ENGINEERING PROGRESS ABROAD

Engineering Library

OCT 1 1942

VOL. III. No. 8 AUGUST, 1942

CHURCHILL Automatic Sizing Internal Grinders are setting up new standards of accuracy and high production in leading factories—everywhere.



THE CHURCHILL MACHINE TOOL CO. LTD., BROADHEATH, Nr. MANCHESTER

THE ENGINEERS' DIGEST

REVIEW OF ENGINEERING PROGRESS ABROAD

Published Monthly at 120, Wigmore Street, London, W. 1.

Publishers : **ENGINEERS' DIGEST LTD.** - - - - Telephone : WELBECK 9357

Advertisement Dept. - 120, Wigmore Street, London, W.1 - Telephone : Welbeck 9357

Distribution - - E. & F. N. SPON, LTD., 57, Haymarket, London, S.W.1
Telephone : Whitehall 1860. Telegrams : Fenspon, Lesquare, London

Editorial Dept. - - 120, Wigmore Street, London, W.1 - Telephone : Welbeck 9357

Subscriptions to : ENGINEERS' DIGEST LTD., 120, Wigmore Street, London, W.1, or
E. & F. N. SPON, LTD., 57, Haymarket, London, S.W.1

ANNUAL SUBSCRIPTION OF 12 NUMBERS, £2 2s. SINGLE COPIES, 4s. 6d.

ADVISORY COMMITTEE

J. F. ALCOCK, B.A., A.M.I.Mech.E.
E. ALTON, D.Eng., A.M.Inst.B.E.
H. H. ASBRIDGE, M.B.E., M.I.Mech.E.
R. W. AYERS, M.I.W.
Col. J. BOWDEN, M.Inst.C.E., M.I.Mech.E.
H. H. BROUGHTON, M.I.Mech.E.
F. BUCKINGHAM, B.Sc., A.M.Inst.C.E., A.M.I.Mech.E.,
T. H. BURNHAM, B.Sc. (Lond.), A.M.I.Mech.E. [A.M.I.E.E.
J. S. CASWELL, M.Sc., M.I.Mech.E.
G. C. SAFFERY COOPER.
J. DICK, Ph.D., B.Sc., A.M.I.Mech.E.
D. FIFE, M.I.Mech.E.
G. E. FOXWELL, D.Sc. (Lond.), F.Inst.P., F.Inst.F., M.Inst.
R. GRIFFITHS, M.Sc. [Gas.E.
H. HEYWOOD, Ph.D., M.Sc. (Eng.), A.M.I.Mech.E.
O. HURST, M.Inst.N.A.
Capt. J. S. IRVING, M.I.Mech.E., M.I.A.E., A.F.R.Ae.S. M.S.A.E.
F. C. JOHANSEN, M.Sc. (Eng.), M.I.Mech.E., F.R.Ae.S., M.I.Loco.E.
W. J. KEARTON, D.Eng., M.I.Mech.E., A.M.Inst.N.A.
Prof. W. KERR, Ph.D., M.I.Mech.E.
G. V. LOMONOSOFF, Dr.Ing., M.I.Mech.E.
B. J. LYMER, M.I.Mech.E.
D. T. MacIVOR, M.I.Mech.E., M.Cons.E.
W. O. MANNING, F.R.Ae.S.
R. B. MATTHEWS, Wh.Ex., A.M.Inst.C.E., M.I.E.E., F.R.Ae.S.
Prof. A. L. MELLANBY, D.Sc., LL.D., M.I.Mech.E.
J. H. R. RATCLIFF, B.Sc. (Eng., Hons.), M.I.Mech.E.
Col. C. W. D. ROWE.
W. A. SCOBLE, D.Sc., A.R.C.Sc., M.I.Mech.E.
P. W. SEEWER, D.E. (Zurich), M.Inst.C.E., M.I.Mech. E.
Prof. S. PARKER SMITH, D.Sc., M.I.E.E., A.M.Inst.C.E.
C. E. H. VERITY, A.M.Inst.C.E., A.M.I.E.E., A.M.I.Mech.E.
E. G. WALKER, F.C.G.I., B.Sc. (Eng.), M.Inst.C.E., M.I.Mech.E., M.Am.Soc.C.E.
Major F. L. WATSON, M.Inst.C.E., M.I.Mech.E.
G. WATSON, M.Inst.C.E., M.I.Mech.E.
C. H. WOODFIELD, M.I.Mech.E., M.I.Struct.E.
T. WRIGHT, Ph.D., M.Sc.
M. L. YATES, M.Sc.Tech.. M.A. (Com.), M.I.Mech.E.

STEEL MAKERS SINCE 1776
PITHO
NON SHRINK
OIL-HARDENING STEEL.
FOR GAUGES, TAPS AND ALL PRECISION TOOLS. ENSURES MAXIMUM DEGREE OF ACCURACY AFTER HARDENING.
SANDERSON BROTHERS & NEWBOULD LTD, SHEFFIELD, ENGLAND.

T

ck 9357
ck 9357

ck 9357

6d.

R.Ae.S.

E.
E.
ech.E.
Soc.C.E.

CONTENTS

AERONAUTICS: *page*

Blohm and Voss BV 141, the first Asymmetrical Aeroplane 265
"*The Engineers' Digest*," *Vol.* 3, *No.* 8, *p.* 265.

ELECTRICAL ENGINEERING:

Electrical Water Turbine Speed Regulator, Type Brown Boveri 274
"*The Engineers' Digest*," *Vol.* 3, *No.* 8, *p.* 274.

The Economic Life of Incandescent Lamps 277
"*The Engineers' Digest*," *Vol.* 3, *No.* 8, *p.* 277.

Fire Extinguishers in High Tension Plants 284
"*The Engineers' Digest*," *Vol.* 3, *No.* 8, *p.* 284.

A New Three-Voltage Distribution System 291
"*The Engineers' Digest*," *Vol.* 3, *No.* 8, *p.* 291.

MECHANICAL ENGINEERING:

Economy of Coal-Dust Engines 267
"*The Engineers' Digest*," *Vol.* 3, *No.* 8, *p.* 267.

Fatigue Tests by Means of Vibrators 275
"*The Engineers' Digest*," *Vol.* 3, *No.* 8, *p.* 275.

Piston Design for Longer Endurance 279
"*The Engineers' Digest*," *Vol.* 3, *No.* 8, *p.* 279.

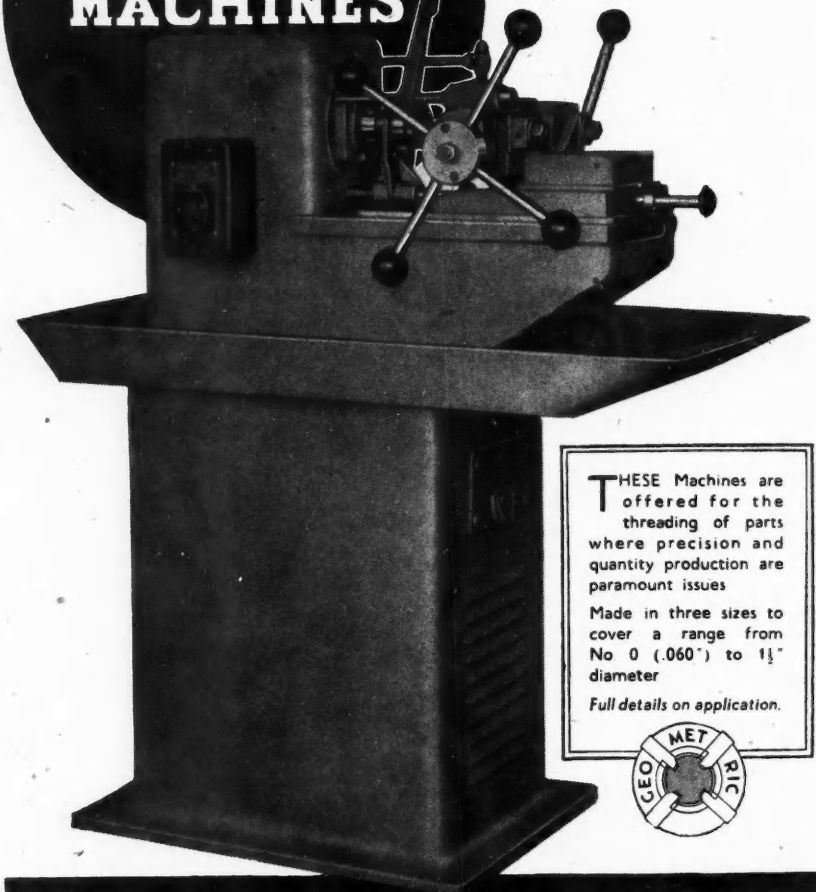
Measurement of Dust in Flue Gas 285
"*The Engineers' Digest*," *Vol.* 3, *No.* 8, *p.* 285.

METALLURGY:

Powder Metallurgy of Tin 271
"*The Engineers' Digest*," *Vol.* 3, *No.* 8, *p.* 271.

Scarfing High Carbon and Alloy Steels.. 282
"*The Engineers' Digest*," *Vol.* 3, *No.* 8, *p.* 282.

Geometric PRECISION THREADING MACHINES



THESE Machines are offered for the threading of parts where precision and quantity production are paramount issues

Made in three sizes to cover a range from No 0 (.060") to 1½" diameter

Full details on application.

GEO MET RIC

BUCK & HICKMAN LTD.

WHITECHAPEL ROAD, LONDON, E.1.

BRANCHES

BIRMINGHAM 27-32, WHITTALL ST

GLASGOW 49, ROBERTSON ST

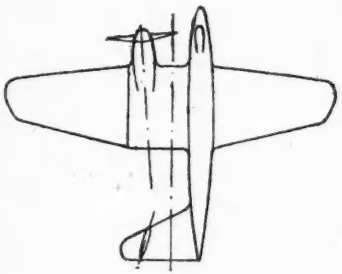
MANCHESTER 247-257, DEANSGATE

BLOHM AND VOSS BV 141, THE FIRST ASYMMETRICAL AEROPLANE.

By DR. ING. RICHARD VOGT, Hamburg. (From *Luftwissen*, Vol. 9, No. 5, May, 1942, pp. 138–141).

WE reproduce here an article, written by the chief designer of the much discussed aircraft, Blohm and Voss, which should serve to dispel any doubts on this misinterpreted design.

To show the development of the idea of asymmetrical aeroplane, we reproduce a drawing of the original patent specification No. 500,541 (by permission of the Controller of His Majesty's Stationery Office).



That the idea is still capable of further development is best documented by various recent patents taken out on the subject by the firm Blohm and Voss. These are:—"Increasing Longitudinal Stability by Making Tail Plane Asymmetrical with regard to Slipstream," Pat. No. 719,428 (*Flugsport*, Vol. 34, No. 9, p. 113, 29/4/42) and "Arrangements of Power Plant on Multi-Engined Aircraft with Offset Fuselage," Pat. No. 719,412 (*Flugsport*, Vol. 34, No. 10, 13/5/42).—EDITOR.

* * *

A patent on an asymmetrical aeroplane, taken out in 1937, gave rise to various comments in the technical press.

The Swedish paper "Flygning," February, 1940, gave a favourable criticism of the idea. In Germany, however, it remained either unnoticed, or wrong conclusions were drawn from it. It has been assumed, for instance, that asymmetry is adopted to distribute the masses along the span with a view of reducing the bending moment. Another interpretation in the English paper "Flight" published last year also missed the essentials of the idea.

In 1937, in a competition sponsored by the German Air Ministry, the type to be built was specified, for economical and tactical reasons, as a single-engine aeroplane giving the best possibilities for ground observation.

When tackling the problem, it became soon clear to the author that with the orthodox layout no satisfactory solution could be reached. The most suitable place for observation being taken up by the engine, there are only available various windows or "blisters" in the top and bottom of the fuselage. The object, therefore, was to obtain the advantages of a twin-engine layout, as given by the fully transparent fuselage nose, in a single-engine aeroplane. With a bold stroke, removing one of the two engines, the "single-engined twin engine layout" was obtained. Thus the idea of the asymmetrical aeroplane was born.

This layout is superior to a twin-engine aeroplane with one engine stopped where the running engine has to supply the power necessary to overcome the drag of the idle engine. A hint as to the practicable solution of offset engine thrust was given by the fact that it is not indifferent whether the right or the left-side engine is idling. This gave cause to consideration of torque and thrust of the airscrew and their mutual effect.

Thrust and torque are interconnected; at maximum offset thrust the torque, too, has its maximum value. Therefore, the asymmetry must be such as to compensate for unbalance owing to offset. This has been effected very simply by making use of the rudder unit in the slipstream.

If, as in Germany, one uses a clockwise rotating engine, then the engine must be at the left, and the fuselage for the crew at the right of the centreline of the aeroplane. This layout is shown in Fig. 1 together with the equations of equilibrium. The yawing moment due to the offset (*a*) of the engine thrust (S) is balanced by the force (Q) on the fin which has a certain angle of setting, and the distance of which from the yawing axis is (*l*).

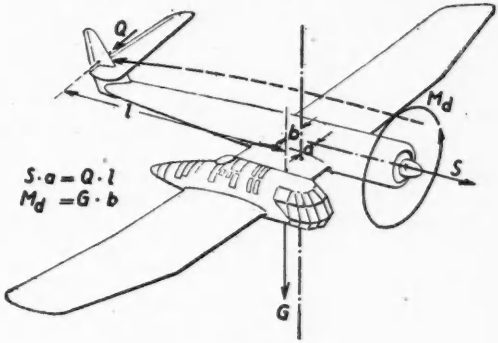


Fig. 1

This method of compensating for the asymmetrical thrust gave satisfactory results. For example, when changing from level flight to climb this aeroplane does not produce that strong "swing" as with other single-engined aircraft. Thus one is justified in making the novel statement that the asymmetrical aircraft is more symmetrical, in certain respects, than the orthodox one.

By spanwise displacement (*b*) of the centre of gravity from the centre of aircraft the torque reaction of the airscrew has been compensated. (In Fig. 1., M_d = Torque, G = Weight of aircraft). This self-balance is lacking in orthodox aircraft, where the torque is generally compensated by trimming the ailerons.

In the above-mentioned design competition, the firm Blohm and Voss was not supposed to secure a contract. However, thanks to the initiative of the late Lieutenant-General Udet, a prototype was ordered, and just a year later flight tests were carried out causing surprise and amazement to all who were called upon to compare the performances of this type with orthodox aircrafts. The flying qualities were so satisfactory that Udet flew rolls, loopings and other aerobatics.

A comparison of the asymmetrical aircraft with the English Lysander, designed at about the same time for

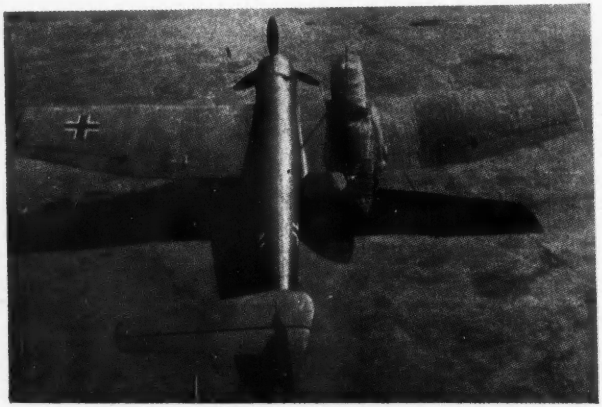


Fig. 2

the same purpose is given in Table I. The Lysander is a two-seater, and a smaller aircraft than the BV 141.

TABLE I.

	Lysander (No tank protection).	BV 141 A (Tanks protected).
Wing area	24m²	43 m²
Airframe	1,055 kg.	1,640 kg.
Power Plant	785 kg.	1,030 kg.
Crew	200 kg.	300 kg.
Fuel	330 kg.	400 kg.
Useful load	310 kg.	460 kg.
Total weight	2,680 kg.	3,830 kg.
Speed at 3,500 m.	368 km/h	388 km/h
Rate of climb at sea level ..	8.4 m/sec.	9.5 m/sec.

In the course of further tests new military advantages of this layout became apparent. The rear gunner has an excellent view and firing field which by far outweighs the disturbing influence of the boom carrying the tail unit. It should not be overlooked in this connection that the easiest defensive manœuvre is a rolling movement as no change in direction of flight or altitude is required. Thus an attack from the boom side is easier to beat off than that from the rear on a orthodox aircraft where the tail unit is obstructing the view and firing angle. By making the tailplane asymmetrical with regard to the slipstream, not only has the stability increased, but an improved firing sector provided for the rear gunner (Fig. 2).

This fact can be exploited in a general way with the orthodox single-engine aeroplane, by reducing the horizontal tail surfaces on the sinking side of the slip stream.

After the tests had successfully been concluded, orders were received for the BV 141 B fitted with the much more powerful BMW 801 engine, making it possible to use the aircraft for special purposes.

About the construction the following particulars can be said :—

Side by side with the pilot, the observer is seated, so that he can conveniently reach all instruments and apparatus grouped around him. To this end his seat is made sliding longitudinally. The boom, carrying engine and tail unit is a monocoque structure. It is of greatest possible strength and rigidity for its weight, having no cut-outs at all. The wing-spar is a tubular one, characteristic to all B. & V. aircraft. The outer wing panel is shown in Fig. 3, the inner wing in Fig. 4. The wing covering all around the aerofoil with the exception of a strip on the pressure side for mounting of the spar is built in spanwise sections allowing for mass-production and ease of replacement for damaged sections. Ailerons are in the outer wing only ; hydraulic flaps in the inner wings.

The wheel track width is considerable (Fig. 5) to give in certain cases, say, at start with following wind, a

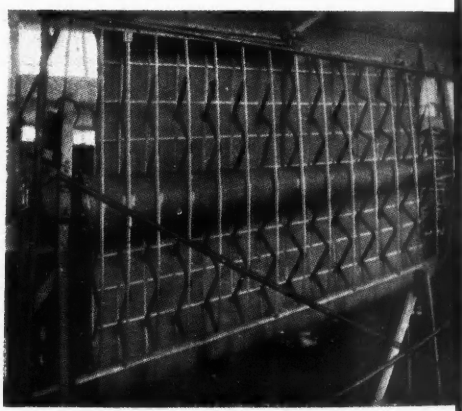


Fig. 3

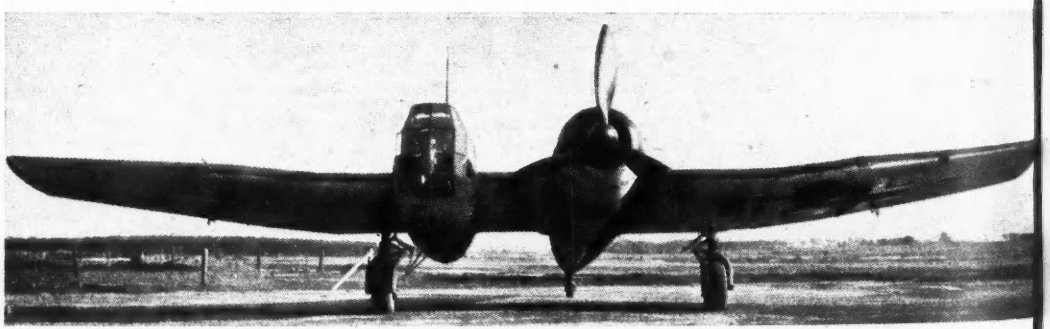


Fig. 5

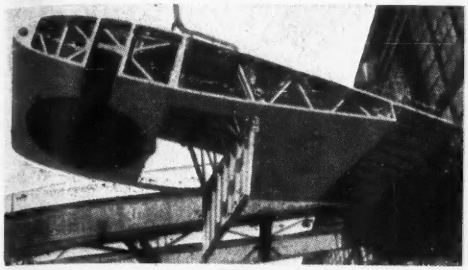


Fig. 4

possibility of compensation of the airscrew thrust moment which is turning the plane about the right-hand side wheel. This moment must be counteracted by the braking moment of the left-hand side wheel. However, as soon as the slipstream acts on the fin, the behaviour of the aeroplane is quite normal.

The under-carriage folds outwards, into cut-outs of the wing, in front of the tubular spar.

Summing up, it can be said that with the asymmetrical aeroplane a type has been created which is unequalled by single-engine aircraft for observation purposes, and the performance of which can be reached in single-engine aircraft of orthodox type only by still greater sacrifice of visibility.

ECONOMY OF COAL-DUST ENGINES

By H. WAHL. (From *Die Wärme*, Vol. 65, No. 18, May, 1942, pp. 159-165).

THE coal dust engine can be expected to become established only if in addition to satisfying technical requirements, it is found to possess economic advantages. From the economy angle in particular there have been unreasonably high expectations, even by experts, as to the future development of such engines. The reason for this was probably a rather superficial comparison between diesel oil and coal-dust prices, and/or catchwords like "direct transformation of energy." When investigations were ultimately carried out to establish more scientifically the possible economy of coal-dust engines, some surprising facts were revealed; the technical limitations of development are quite different when the sole aim is a "technically perfect" machine compared with the fulfilment of rigorous economical requirements.

Whether or not the use of coal-dust engines is a tempting proposition, depends upon the result of a comparison with all available sources of energy. Hence its future prospects and the justification of development should be viewed in the light of its advantages over diesel engines as well as over steam engines (turbines and reciprocating type), producer-gas engines and water turbines as direct or indirect means (electricity) of power generation.

The discussions of economy in the sections below are based on careful examination of the following details :—

Cost of production, pulverisation, storage and packing of coal-dust.

Transportation costs of coal-dust.

Operational costs of diesel, producer-gas, coal-dust, and steam engines.

For the purpose of these investigations the operational data of a 160 H.P. single cylinder coal-dust engine that has been in operation for many years was taken as a basis, together with experience gained from the re-calculation, design, construction and short practical testing of a 600 H.P. six-cylinder engine.

It must be realised, of course, that the present development of the coal-dust engine is very far from being advanced; but this does not restrict speculation on its future economics, since modern technique provides sufficient examples as to what can be expected from careful research and development. In many factors affecting economy, therefore, future development was taken into account for the purpose of this article.

In general the economics of engines depends on the following: capital investment, operational (fuel) costs, maintenance cost, lubrication and attendance costs, and miscellaneous expenditure.

These items, with the exception of operational (fuel) costs will probably be the highest for coal-dust engines. Any economical advantages it may possess can only result, therefore, from cheap running costs. The chief competitors will be steam engines and producer-gas engines, since both these utilize the same sort of fuel as coal-dust engines. Their efficiency lies in the neighbourhood of 25 per cent. and 21 per cent. respectively; the efficiency of coal-dust engines under favourable conditions, and considering the thermodynamics of diesel operation, may reach about 33–40 per cent. Thus at the best their operational cost will be below that of steam plants, but increased somewhat by higher costs of all other factors.

The possible economical gains with coal-dust engines are, as can be seen, very limited and within a narrow margin of other types of engine.

Capital Expenditure.

Because of the higher stressing of engine parts and some technical pecularities, the manufacturing cost of coal-dust engines will be inherently higher than that of other types of engines. This is especially so if not only the "naked" engine is considered but also indispensable auxiliaries and factors connected with its manufacture and influencing the capital costs (*e.g.*, licence).

It is true that the benefit of many years practice in the development of large manufacturing plants, etc., cannot yet be accredited to the manufacture of coal-dust engines and the cost of the first models was therefore very much in excess of that of diesel engines* (80 RM/B.H.P.), or gas engines (100 RM/B.H.P.), being approximately 400 RM/B.H.P. for the 160 H.P. Elbinger type (180 r.p.m., 4-stroke, single cylinder) and 300 RM/B.H.P. for the second model, a 600 H.P. six-cylinder engine (375 r.p.m.). From another source prices of the order of 198–252 RM/B.H.P. are quoted. Therefore, it is imperative that these prices should be reduced by at least 50 per cent. before serious consideration can be given to the use of coal-dust engines.

To reduce the weight of engine unit horse power two methods may be used. The first is to increase the engine speed. The speed of the 160 H.P. engine was 180 r.p.m. and the weight was 160 kg/H.P. By increasing the speed of the 600 H.P. model to 375 r.p.m., the weight was reduced to 67 kg/H.P. Although at present much higher speeds are not feasible, the solution for this may not be long delayed.

A second way to reduce the weight of the engine might be to adopt the two stroke cycle. It is expected that in this way the weight will be easily reduced to 40–50 kg/B.H.P. Considering now that the average

* 1£ = 20 RM. (pre-war).

weight of, say, marine diesels is similarly 40-50 kg/B.H.P. it becomes obvious that there is but little connection between capital expenditure and weight of engine. A very comprehensive analysis of the 600 H.P. Elbinger engine shows that the manufacturing cost of practically every group of engine parts is increased by the unique features of coal-dust engines. To reduce these extra costs, many more years careful research and redesigning will be needed, but coal-dust engines will probably always be more costly than other types.

Closely related to this is the question of cost of the auxiliaries, such as a continuous oil cleansing apparatus, separate lubrication for cylinders and driving mechanism, special starter, etc. An indispensable auxiliary is a coal-dust conveyor. Fully automatic conveyors are too expensive for small and medium size engines, and for these only very simple, hand-operated devices are practicable, though they require more attendance and are not so clean in operation.

Considering the foregoing factors, it could hardly be expected that future development will reduce the manufacturing cost of coal-dust engines below the following figures :—

100 H.P. engines	..	180 RM/B.H.P.
500 H.P. engines	..	160 RM/B.H.P.
2,000 H.P. engines	..	125 RM/B.H.P.

Owing to the higher stresses in coal-dust engines, their working life will be probably reduced, and hence higher amortization should be allowed :

10 per cent.	amortization
6 per cent.	interest on capital
1 per cent.	Insurance
17 per cent.	

Assuming 2,000 operational hours/year the cost will become :

1.53 Rpf.*/B.H.P.	h.	for	100 H.P. engine.
1.35 Rpf./B.H.P.	h.	for	500 H.P. engine.
1.06 Rpf./B.H.P.	h.	for	2,000 H.P. engine.

*(Note 1 Rpf. = 1/100 RM.)

Fuel Costs.

This, as was pointed out before, is the only "credit" item in the cost sheet of coal-dust engines, hence a very careful examination of all factors affecting fuel costs is necessary.

The first item is the cost of fuel delivered to the engine valve. There being no practical experience, it was essential to consider this problem very carefully from every angle, *e.g.*, cost of supplying coal-dust ready for use, or supplying coal and pulverizing it on site. The following detail problems were examined in the course of making the calculations :—

(i) Quality of fuel for optimum results.
(ii) Influence of method of fuel transportation.
(iii) Influence of fineness of coal-dust.
(iv) Possibility of saving by (*a*) using cheaper fuel, (*b*) reducing conveyance costs, (*c*) reducing loading and packing costs.
(v) Comparison between unit heat costs of coal-dust and other fuel types.

Only a few results of the investigations can be given here.

Within the whole range investigated, *i.e.*, from 100 to 2,000 H.P., and 2,000 working hours a year, both technical and economic considerations are strongly in favour of purchasing ready-for-use coal-dust instead of preparation on site (Fig. 1). Only with larger engines and higher yearly working hours is it more advantageous to prepare the coal-dust locally.

(i) Brown coal was found to give lowest fuel prices.

(ii) The influence of method and distance of transportation is illustrated in Fig. 2, the fuel being of brown coal of fineness = 20 per cent. residue through a screen of 70 mesh.

(iii) Finer coal-dust than 20 per cent. residue through 70 mesh is not economical as the gain by improved combustion is more than outweighed by higher production costs of the fuel.

(iv) When ready for use coal-dust is used, the raw material and transportation costs make up 70–90 per cent. of the total fuel price, hence there is very little hope for further reduction in fuel costs.

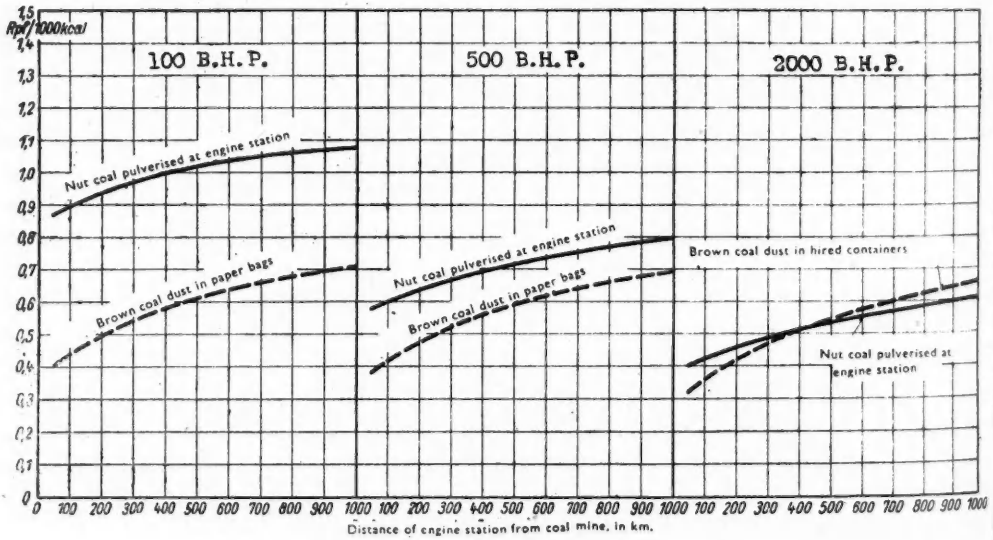


Fig. 1

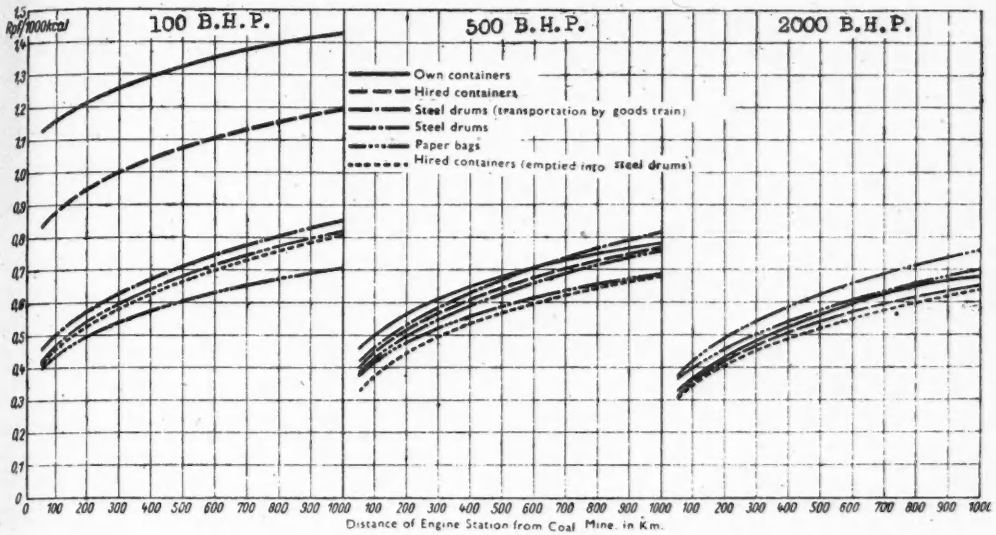


Fig 2

The second important question is the specific fuel consumption. The theoretically minimum quantity of fuel will be given by the laws of diesel operation; the actual efficiency will be lower than that obtained in diesel engines (33–40 per cent.) even under the most favourable conditions, due to higher wear of the pistons, etc.

The author's opinion, supported by practical observation, is that an average figure for fuel consumption to be expected is 2,100–2,200 Kcal/B.H.P. with a fuel of the above specified fineness. This figure will be obtained with moderate lubrication, without compressor, in medium powdered, relatively low speed engines.

As a summary therefore the following are the anticipated running costs of coal-dust engines :—

Power in H.P.	100	500	2,000
Coal-dust free delivered to engine in Rpf./1,000 Kcal.	0.55	0.50	0.45
Fuel Consumption in Kcal./B.H.P. h. ..	2,300	2,200	2,200
Cost in Rpf./B.H.P. h.	1.26	1.1	1.0

Maintenance Costs.

The maintenance costs, too, are higher for coal-dust engines; this follows from the greater wear and stresses to which the engine parts are exposed.

TABLE I.

Type of Engine.	Diesel.			Producer-Gas.			Steam			Coal-Dust.		
							Reciprocating.		Turbine.			
Power in B.H.P.	100	500	2,000	100	500	2,000	100	500	2,000	100	500	2,000
Capital Investment Rpf./B.H.P./h.	0.63	0.54	0.48	0.74	0.61	0.53	0.40	0.40	0.35	1.53	1.35	1.06
Fuel cost (free delivered to engine valve) Rpf./B.H.P./h.	4.90	4.42	4.10	2.56	1.96	1.57	3.61	2.22	1.98	1.26	1.10	1.00
Maintenance costs Rpf./B.H.P./h.	0.25	0.22	0.16	0.30	0.27	0.20	0.10	0.10	0.04	0.70	0.50	0.30
Lubrication costs Rpf./B.H.P./h.	0.20	0.20	0.14	0.24	0.18	0.15	0.15	0.15	0.05	0.30	0.25	0.20
Attendance costs Rpf./B.H.P./h.	0.50	0.25	0.11	0.50	0.25	0.11	0.50	0.10	0.20	1.00	0.50	0.20
Other costs Rpf./B.H.P./h.	0.14	0.08	0.06	0.12	0.08	0.07	—	0.56	0.15	0.17	0.10	0.08
Total Rpf./B.H.P./h.	6.62	5.71	5.05	4.47	3.41	2.66	4.76	3.53	2.77	4.96	3.70	2.84

At the beginning of experiments with the 160 H.P. type engine the maintenance cost was 9 Rpf./B.H.P. h. which was reduced to 0.7 Rpf. after some 6,000 hours running. It was also found from calculations that maintenance costs as low as that of Diesel engines cannot be expected. As an example, an investigation of cylinder liners shows that by changing the working material to harder types the working life can be considerably increased, but at the same time the maintenance costs are also increased, so that economic considerations set a limit to technical development.

In view of what has been said above, the following maintenance costs can be regarded as favourable :

For small engines	..	0.7 Rpf./B.H.P.h.
For medium engines	..	0.5 Rpf./B.H.P.h.
For large engines	..	0.3 Rpf./B.H.P.h.

Lubrication Costs.

Although the best lubrication system for coal-dust engines has not yet been established, from a technical point of view, a very generous lubrication is warranted. As, however, the losses during cleaning the oil are proportional to the quantity of impurities in it, a high oil consumption must be expected in coal-dust engines. As average lubrication cost in future engines, the following figures may be expected :—

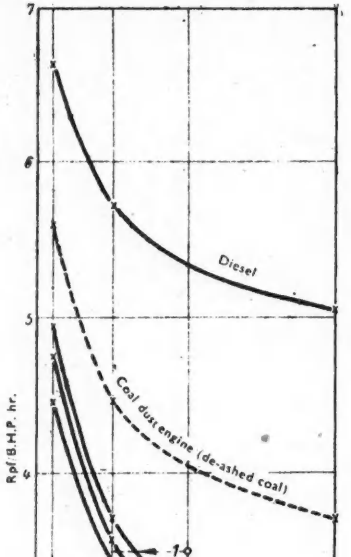


Fig. 3

For small engines	..	0.3 Rpf./B.H.P.h.
For medium engines	..	0.25 Rpf./B.H.P.h.
For large engines	..	0.20 Rpf./B.H.P.h.

Overall Operational Costs and Economy.

Table I. and Fig. 3 give an approximately true picture of the economics of coal-dust engines as compared with steam plants, diesels and producer-gas engines. The figures for coal-dust engines are substantially below to-day's average prices, since the anticipated reduction in cost as a result of further development is allowed for. By contrast the operational costs of the other engine types represent current prices.

From this comparison the following general conclusions can be drawn :—

The coal-dust engine—within the range investigated (100–2,000 H.P.)—operates at lower cost than diesel engines. This, however, is of little importance, as the applications of diesel and of the coal-dust engines are not following parallel paths.

From the cost angle it is established as a principle of great importance that no forceable further development of coal-dust engines seems to promise a reduction of operational costs sufficient to beat steam engines or producer-gas engines. For many more years to come, the coal-dust engine will not be able to compete with these two types of engine.

The dotted curve in Fig. 3 shows the impracticability of using de-ashed coal (50 RM/t.).

By far the most important factor in the economics of the coal-dust engine is its competition with the electric power supplied from the mains. In this connection the following points should be considered :—

(1) When converting operational costs into Rpf./kWh on the low tension side, both the electric losses (for the 500 and 2,000 H.P. engines and the transformer losses) must be considered.

(2) The cost so obtained must be increased by allowing for building costs, cost of a generator-transformer set, switch plants, etc., which have not hitherto been taken into account.

(3) Provision must be also made for a standby plant. If this is also a coal-dust engine, then the overall costs will be increased by about 20–30 per cent.

(4) Finally, as 2,000 working hours/year at full load is highly improbable in practice, allowance must be made for higher costs due to operating at lower loads.

In view of the above considerations, the following prices appear to be justified :—

Engine Power	Coal-Dust Engine.	Power from Main.
	Rpf./kWh	Rpf./kWh
100 H.P.	11 to 15	(8, 5)* to 11, 5†
500 H.P.	8 to 12	(5)* to 8†
2,000 H.P.	7 to 9	(5)* to 7†

*=lowest day charge. †=mean day charge.

Also since there seems to be very little advantage to be gained, the use of coal-dust engines should be considerably handicapped by competition with the simple method of drawing power from the mains.

It will be clear, therefore, that the prospects of coal-dust engines are nothing like so rosy as it is usually depicted, especially considering that it will take many more years careful planning, research and improvement until it becomes a match for diesel, steam or gas-engines. At the same time, it has nothing to offer from the point of view of National economy.

POWDER METALLURGY OF TIN.

By H. C. WATKINS. (From *Metals and Alloys*, Vol. 15, No. 5, May, 1942, pp. 751–757).

LITTLE of value has been published on the manufacture of tin powder as most of the processes are kept secret by the producers. The small amount of information that has appeared is not readily available, and is scattered through a large number of technical papers. The main object of this report is to collect together the scattered data on tin and tin alloy powders with a view to obtaining a clearer conception of the methods by which the powders are prepared and the principal uses to which they are put.

Manufacture of Tin Powder.

The following three methods are quoted in the literature as being used for the production of most of the tin powder used commercially :—

(*a*) Atomization.
(*b*) Chemical precipitation.
(*c*) Electro-deposition.

Coarser tin powders may be made by (*d*) Shotting or Granulating, and (*e*) by Graining.

Atomization.—Atomization consists essentially in the forcing of a thin stream of molten metal through a small orifice and hitting this stream with steam or compressed air or gas, which disintegrates and solidifies the metal into finely divided particles of ragged "tear drop" shapes. In one application of this method, steam or compressed air that has been preheated to approximately the melting point of tin (232° C) is directed through a nozzle (partly submerged in the molten metal) in such a manner as to draw the metal up through a tip that is inside the nozzle. By proper design and arrangement of the nozzle and tip assemblies, by adjustment of steam, air or gas pressure, and by varying the viscosity of the molten tin through control of the amount of superheat of the metal, the degree of fineness of the atomized product can be regulated over a considerable range. The atomized tin is carried off under suction to a dust-collection system such as a cyclone dust collector and baghouse.

Steam or compressed air might be expected to result in excessive oxidation, but this does not occur because of the rapid chilling effect of the expanding gases released through the nozzle. Tin, when atomized with compressed air, contains less than 0.2 per cent. oxygen as oxide. The thin film of oxide produced during atomization with steam or air is sufficient to prevent further oxidation of the powder.

It is possible to produce powder of a considerable range of fineness by the method just described, but for coarser powders that are required to contain a minimum of fines, the cross-jet method is better. In this a stream of molten tin is forced through an orifice, or is otherwise allowed to pour into a jet of steam of compressed air directed substantially at right angles to the stream of molten metal. The problem of dissipating the heat is greater with this method because of the slower cooling of the somewhat larger particles. A larger collecting system must be used.

Atomized tin is used for moulding work of various kinds, *e.g.*, in production of porous bronze bearings.

Chemical precipitation.—Tin powder is produced from stannous chloride solution by precipitating with scrap zinc. This process is sometimes used in the recovery of tin from tin plate scrap. The latter is heated with chlorine and the resulting stannic chloride distilled off, reduced to stannous chloride and the tin precipitated as a grey powder by means of zinc. This powder has a tin content of about 79 per cent., and consists of very fine granules. Impurities include stannous chloride, ferrous chloride, zinc chloride and water.

Tin powder produced by this method is extremely fine, and is used principally in coating paper and for moulding work.

Electro-deposition.—Although reference is made in the literature to the fact that tin powder is produced commercially by electro-deposition, no details are given regarding the electrolytes employed, and the conditions of electrolysis which must be employed. It appears from the patent literature that an acid tin chloride solution is used, but it has not been possible to confirm this. Very good powdered tin is also said to be produced by electrolyzing a solution containing about 4 oz. per gallon of tin perchlorate with a slight excess of perchloric acid.

In general, the acid electrolytes used for producing powders contain a relatively low concentration of the metal, and a high concentration of acid as compared with electrolytes used for plating. A relatively high cathode current density is usually employed. Under these conditions, a loosely adherent, spongy deposit is produced on the cathode, which may be periodically removed by various means such as scraping and "rapping" devices, and to a certain extent by rapid circulation of the electrolyte past the surfaces of the cathodes.

It is important that the metal deposit on the cathode be removed at frequent intervals, because if it is allowed to build up, the surface area of the cathode is thereby increased and the cathode current density lowered to such an extent that the deposit becomes too coarse and tends to plate out. In order to ensure uniformity of particle size of the deposit, it is, of course, also necessary to control the temperature and composition of the electrolyte carefully. By changing the composition and temperature of the electrolyte, and particularly by varying the cathode current density, the fineness of the powder produced can be varied over a considerable range. Addition agents (*e.g.*, glucose) may also be used to improve the uniformity of the powder produced or to modify the type of deposit to meet specific requirements.

The deposited powder must be thoroughly washed to remove all electrolyte, as even small amounts of salts left with the dry powder will cause rapid oxidation when exposed to the atmosphere. It is usually advisable, after thoroughly washing the powder, to dry the sludge in a vacuum or inert atmosphere, keeping the powder from contact with air until it has been dried and cooled to approximately room temperature. When the powder is to be used subsequently in wet products or processes using solder pastes, the drying process may be omitted.

Some powders are heated in an inert or reducing atmosphere after drying, which has a tendency to improve keeping properties of the powder and tends to increase its apparent specific gravity by partial knitting together of the particles.

The hardness of the particles may be varied by controlling the drying conditions. Soft powders are obtained by drying with alcohol or similar liquids, while hardness is increased by gas-drying at higher temperatures.

After washing, drying and rubbing, the powder is carefully separated into sizes by a series of screens and bolting cloths of closer and closer weave. The very finest particles are removed and classified by an ascending air current.

Powders finer than 250 mesh can be prepared in this manner, but the most important feature of the process is the fact that it is possible to work closely to specified screen analyses and loading weights. These powders are generally remarkably pure, free from oxide, and uniform in their characteristics and are well adapted to molding work.

Shotting.—A relatively coarse and roughly spherical shot powder can be produced from tin by pouring the molten metal through a screen or through small orifices, allowing the globules to solidify as they fall in air and finally collecting them in water. The height of drop and size of orifice determine the size and shape of the particles. The water serves as a cooling medium and prevents agglomeration of the particles.

When the granulated products may be irregular in shape, the molten tin may be dropped directly into water. Finer particles may be made by directing a stream of compressed air or steam against a stream of the molten metal before it reaches the water.

Graining.—A rather coarse tin powder, known as "grain tin," may be produced by heating a rod of somewhat impure tin to a temperature of about 200° to 220° C and then pulverizing the tin, for example by hammering. The fusible constituents formed by the impurities cause the tin to fracture at the grain boundaries. A brand of tin containing a relatively large impurity of lead is most suitable for this purpose.

Manufacture of Tin Alloy Powders.

The methods of atomization and shotting or granulating described above can be employed also for the production of certain tin alloy powders, *e.g.*, tin-lead solder powder. A number of other methods are also applicable and these are as follows :—

(*a*) Machining.
(*b*) Pulverizing.
(*c*) Agitation of the liquid alloy.
(*d*) Sintering.

Machining.—This type of operation is used for the production of the relatively coarse alloy powders used in the dental trade. These are alloys of silver with copper, tin and zinc, and are supplied in the form of filings ready to be amalgamated immediately before use. The quantity of the alloy produced is not so great as to make this rather crude method impracticable from a cost standpoint, particularly since the rather excessive cost of the operation is not too great in relation to the cost of the alloy itself. Freedom of the powders so produced from extreme fines or "slimes" is partly responsible for the selection of this type of process for manufacturing dental alloy powders. The exact machining operation used depends entirely on the ingenuity of the operator in adapting commonly known machining operations to produce in the most efficient manner the size and shape of metallic particles required. A file held in the frame of a power hacksaw is commonly used for the production of dental alloy powders. The powders are graded by sieving, passed over a magnet to free them from iron contamination, and frequently aged at 100° C. for some hours.

Pulverizing.—Certain brittle copper-tin alloys can be ground to powder in ball or stamp mills. A preliminary crushing or shotting operation may be necessary to break the metal down to a size that can be conveniently handled by the grinder used for the finishing operation. Heavy stamps, jaw crushers, or gyratories are suitable for such preliminary crushing treatment.

Agitation of the Liquid Alloy.—R. W. Rees (J. Inst. Metals, 1935, Vol. 57, pp. 193–195) found that many lead alloys could be broken up into a coarse powder by simple agitation of the molten metal during solidification. Alloys of the following range of compositions have been successfully treated in this way :

Lead	.. .. ..	50 per cent.
Tin	.. .. ..	16–20 „ „
Cadmium	.. ..	10–30 „ „
Bismuth	.. ..	0–50 „ „
Antimony	.. ..	0–10 „ „

An alloy of lead 50, cadmium 30 and tin 20 per cent., and having a freezing range from 180° to 150° C., was found particularly suitable.

If the molten alloy was poured into a wooden tray and shaken vigorously while it solidified, about 10 per cent. of the material was found to pass 100 mesh. A finer powder was obtained by pouring the molten metal into an iron mortar, preheated to a temperature of about 10° C. below the melting point of the alloy, and grinding vigorously while the metal solidified. The addition of a little graphite before grinding prevented the particles from sticking together. The yield by this method was about 40 per cent. through 100 mesh, 25 per cent. through 200 mesh.

The method finally adopted was to feed the pasty metal into an impeller-type disintegrator maintained at a temperature of about 10° C. below the solidus. The body of the mill was preheated, but once up to temperature the heat introduced with the hot charge was sufficient to maintain the temperature at the desired value. The shaft carrying the impeller blades was belt-driven at a speed of about 1,500 r.p.m. When the machine was fitted with a metal screen with perforations 1/64 in. in diameter, the yield was : All through 70 mesh, 80 per cent. through 100 mesh, 30 per cent. through 200 mesh.

The product was discharged into a bag and then sieved through the appropriate screen, any over-size being returned to the heated hopper. The output of such a mill is about 2 cwt. of 200-mesh powder per day.

A method based on the same principle, which is particularly applicable to the production of small quantities of soft solder powder, is as follows :—

A ladle filled with the metal is taken from the melting pot and is allowed to cool until the alloy becomes pasty, stirring the metal constantly with a wooden stick. It is then quickly emptied into a strong linen bag, the upper part of which is twisted around until the metal fits tightly into the bottom section. If the metal is then beaten with a hardwood hammer with smart quick taps, turning the bag constantly, it will fall apart and become a gritty powder within a few minutes.

Providing that the metal is poured into the bags at only a few moments before complete solidification, the bags will not be damaged considerably, and may be used a large number of times. With too high a pouring temperature, the powdered solder becomes dark, or even black, from the carburized particles of the bag. Hammering should be continued until the metal feels only warm to the hands.

Sintering.—Bronze powder may be produced by sintering together copper and tin powders in the desired proportions and grinding the sintered cake to a powder.

The copper and tin powders are first intimately mixed and are then heated in a neutral or reducing atmosphere at a temperature below the melting point of the alloy to be formed. As the melting point of tin is approached, the tin commences to diffuse into the copper to form a bronze alloy, and as the temperature is then increased the tin and copper completely diffuse to form a uniform alloy of the composition represented by the proportions of tin and copper used. The product is a sintered "cake" which may be ground to a powder with little difficulty. Since the sintering temperature used must be above the melting point of tin in order to obtain

complete diffusion of the metals within a reasonable time, the alloy must not contain too high a proportion of tin, otherwise the alloy will fuse to an almost solid mass.

Certain phosphor bronzes can be made by sintering together mixtures of powdered copper, tin and red phosphorus. These alloys cannot be conveniently pulverized when cast in the usual way.

Applications of Tin and Tin Alloy Powders.

The principal uses at the present time are as a decorative medium, in the production of certain powder metallurgical products, particularly porous bronze bearings, and as a constituent of tinning and soldering pastes and powders.

Decorations.

Tin Coated Papers.—The tin powder used for this is usually produced by the chemical precipitation method. An emulsion of the finely divided tin suspended either in a weak gelatine solution, or in alkaline casein is coated on to the paper which is then passed through steam heated calendering machines. These dry out the water and burnish the tin surface giving the metalic appearance.

In the production of the tin-coated paper for electrical condensers—known as Mansbridge paper—the tin is deposited on zinc in earthenware containers, periodically collected, washed, mixed with an adhesive and spread on the paper. The paper is afterwards heavily calendered, with the result that a thin, electrically-continuous film of tin is formed on one side.

Paints and Pigments.—Owing to the high price of tin compared with the metals commonly used as a base for metallic paints it is unlikely that tin powder will ever find extensive application in this field. When tin has been employed it has been added as a constituent of a rust-preventive paint or has been introduced in order to obtain a paint of special colour. Thus a rust-preventive paint which appeared on the market a few years ago had as a base a powdered alloy of lead 83, antimony 13, and tin 2 per cent. A matt silver paint referred to in the literature had a powdered alloy of tin 96.46, zinc 2.30 and iron 0.03 per cent. as a base.

Powder Metallurgy Fabrication.

Bronzes.—Bronzes made from copper and tin powders have a uniformity of composition unapproachable by foundry methods. This is very important for electrical bronzes, and for this reason the powder method has been used for making certain special bronze parts for use in telephone apparatus.

The tin and copper powders must be very thoroughly mixed if a homogeneous and uniform product is to be obtained. For this reason the powders are generally mixed in tumbling mills or continuously sieved for a long time—from 1 to 24 hours—so that each particle of one metal can get close to each particle of the other. Often the mixing operation takes place in a mill or tumbler in a hydrogen atmosphere.

After mixing, the powder is filled into a mould of the desired shape, squeezed so that it coheres, and the pellet heat treated so that the particles weld together at the contact points.

Since the metal particles should be as pure as possible (in order that the properties of the fabricated shapes may be highly uniform), tin and copper powders produced electrolytically are very suitable for this purpose.

Porous Bronze Bearings.—A representative bronze used in the form of porous bearings contains 84.6 per cent. Cu, 9.4 per cent. Sn and 6.0 per cent. graphite. The graphite is added largely for mechanical reasons, and the choice of powder metallurgical technique is made for the two-fold purpose of evenly distributing this graphite and for attaining a porous structure. Porosites varying between the general limits of 0.5 to 40 per cent. can be obtained at will with this technique. Sometimes the porosity is artificially increased by mixing with the powders some volatile salt which volatilizes during heat treatment. This porosity is desired for the following reasons :—

(*a*) To improve the mechanical performance of the bearing.

(*b*) To act as a reservoir for lubricating oil, with which the bearing is impregnated by the manufacturer.

(*c*) To provide a device independent of extraneous mechanical means for continually supplying oil to the working surface. This is achieved because of the inter-communicating nature of the pores, their great number and small size. These pores thus function as a great number of capillary tubes, the oil rising therein to maintain oil contact with the working surface.

Representative samples of copper and tin powders and graphite extensively used by bearing manufacturers have the following characteristics :—

Method of Preparation Screen Analysis Mesh.	Copper Powder Reduction of Oxides. Per cent.	Tin Powder Atomization. Per cent.	Graphite. Per cent.
+150	Trace	Nil	0.1
−150 +200 ..	10.2	0.8	0.8
−200 +250 ..	4.0 }	1.6	4.0
−250 +235 ..	15.3 }		
−325	70.5	97.6	95.1

Particle size distribution as determined by microscopic count :—

Microns.	Copper Per cent.	Tin Per cent.	Graphite Per cent.
0—5	0.5	27.1	1.2
5—10	4.2	30.5	14.8
10—20	20.7	24.5	19.3
20—30	18.4	11.6	16.2
30—40	16.2	2.6	25.6
40—50	10.5	1.3	18.0
50—75	18.3	1.4	4.0
75—100	10.2	1.0	0.8
+100	1.0	Nil	0.1
Apparent Density (or loading weight).	2.50	2.90	0.30

The powders are well mixed in the cited proportions, and the loose mixture is pressed into the form of a sleeve. The compact is then heat treated and afterwards quenched in oil.

The bearing may be formed by feeding the mixed powder to a mould in an automatic briquetting machine and compressing, using a pressure of about 40,000 to 60,000 lbs. per sq. in. The coherence of the metallic particles is such that the bearing may be handled with considerable freedom. Heat treatment may consist merely in dipping the compacts into a cyanide pot or in sintering, for example, at 810° C. for 30 minutes, in a neutral or slightly reducing atmosphere. In either case the time and temperature of treatment are regulated so that there is a true welding action at the multitude of points where metal comes into contact with metal.

Bearings may be impregnated with oil by quenching them in lubricating oil, and allowing them to remain in the oil until the capillary pores are completely filled, or by a process of vacuum impregnation. The amount of oil which can be absorbed obviously depends upon the specific gravity of the metal mass, and this is regulated by the particle size of the constituent powders and the pressure. Very satisfactory bearings for heavy duty contain from 30 to 40 per cent. oil by volume.

Sizing is most important in connection with the manufacture of porous bronze bearings, and in this case it appears to be possible for sintering to take place with little or no alteration in external dimensions. Little is known about the conditioning factors of shrinkage and the contol of it in the manufacture of bronzes is largely an empirical matter. For example, some manufacturers of this class of alloys have a decided preference for copper powder prepared by an electrolytic process, and this preference is largely connected with the shrinkage characteristics of this powder.

Shrinkage can be controlled to some extent by the addition of volatile substances to the pressings. The stearin and graphite which may be added to copper tin powder mixtures for the purpose of producing porous bronzes undoubtedly has some influences in this direction, although stearin is mainly there for facilitating pressing. Electrolytic copper powder, such as is employed for the manufacture of this type of bearing, frequently contains appreciable quantities of carbonaceous residue insoluble in nitric acid. It has been shown that this substance has no appreciable influence on shrinkage.

Porous bronze bearings are mainly employed as follows :—

(*a*) Where the bearing does not require much oil and the amount absorbed is sufficient, as in motor spring shackles.

(*b*) To regulate a gravity supply of oil to journal bearings. These then approach closely the efficiency of the best ball and roller bearings, and give a low coefficient of friction for starting up.

"Oil-less" bearings have been installed for several years in small electric motors for fans and other equipment when expert care cannot be assured. Electric clocks and domestic refrigerators have also used great quantities of them. One of the leading automobiles employs nearly a hundred porous bronze bearings in spring shackle bearings, steering gear bearings, clutch pilot bearings, chassis spring inserts, generator bearings, and water pump bearings.

Tinning and Soldering Pastes and Powders.

Tinning powders consist essentially of pure tin powder intimately mixed with about 50 per cent. powdered flux, usually ammonium chloride. Such powders are sometimes used for the tinning of cast-iron and also for tinning other metals when the normal methods cannot be employed. The powder is spread over the heated metal surface to be tinned, and is then wiped until an even coating is obtained. Once the metal has been tinned, the thickness of the coating may be increased by melting on tin from a stick and wiping it as before.

Soldering pastes facilitate soldering by combining the solder and flux in one preparation. They usually consist of powdered tin or solder mixed with zinc chloride and ammonium chloride, glycerine and water. The percentage of flux may vary between about 10 and 50 per cent.

(The article comprises a comprehensive List of Patent Literature.)

ELECTRICAL WATER TURBINE SPEED REGULATOR, TYPE BROWN BOVERI.

(From an abstract by G. AUGUST in *Zeitschrift des Vereins Deutscher Ingenieure* [VDI], Vol. 86, No. 7/8, February 21st, 1942, pp. 121–122. Original article by H. HAPPOLDT, *Elektrotechnische Zeitschrift* [ETZ], Vol. 62, 1941, pp. 191–193).

CENTRIFUGAL type governors are generally used for the speed and frequency regulation of prime movers. The difficulties arising from the driving mechanism of the pendulum of such governors for water turbines of perpendicular design were overcome by some designers by the use of an electrical instead of a mechanical drive of the pendulum, *e.g.*, by a synchronous motor fed from the generator driven by the turbine. However, such a drive has the disadvantage that the torque of the motor is influenced by heavy variations of the voltage or the frequency of the system. Therefore, Brown Boveri has developed a turbine frequency regulator which uses an electrical frequency measuring system instead of a mechanical element, the pendulum.

The electrical frequency measuring apparatus consists of two systems *t* and *u* (Fig. 1) similar to the stator winding of a squirrel cage motor, which produce torques of opposite directions in the rotor *s*. These systems are fed from the transformer *a* connected to the generator *b*. An adjustable inductance *l* is placed in series with the winding *t*, and a capacitance *v* in series with the winding *u*. When the impedances of the two windings are very low compared with the reactive resistance of *l*, and the capacitive resistance of *v*, the current in one system is almost 100 per cent. inductive, in the other almost 100 per cent. capacitive. The torques produced by these currents have opposite directions, so that *s* does not turn when the torques are equal. The values of the inductance *l* and the capacitance *v* are such that the equilibrium occurs at a frequency of 50 Hz. The adjustable inductance *l* enables to change the adjustment of the regulator to a different frequency. If the

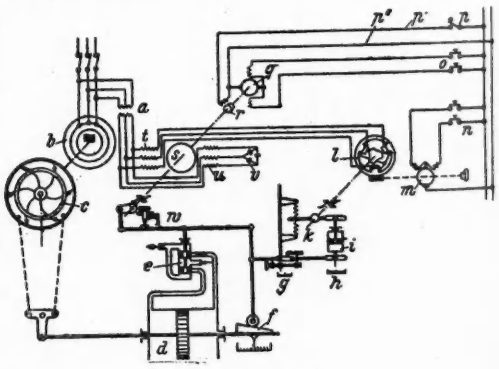


Fig. 1.

Brown Boveri electrical speed regulator.—*a*, transformer ; *b*, generator ; *c*, water turbine ; *d*, servomotor ; *e*, pilot valve ; *f*, slider ; *g*, adjustment of static (characteristic) ; *h*, adjustment of temporary static ; *i*, oil damper ; *k*, restoring element ; *l*, adjustable inductance ; *m*, motor for adjustment of speed ; *n*, speed adjustment ; *o*, switch for remote control ; *p*, switch for inserting remote control ; *q*, remote control ; *r*, electromagnetic clutch ; *s*, rotor ; *t*, *u*, stator windings ; *v*, capacitance ; *w*, restoring of valve.

frequency of the system feeding the frequency measuring system differs from the normal frequency, for which the apparatus has been adjusted, a torque is produced in *s* which works till normal frequency is restored.

The mechanical part of the regulator consists of elements of the usual turbine governor. The shaft of the rotor *s* actuates the pilot valve *e* of the oil pressure gear. The servomotor *d* adjusts the position of the inlet of the turbine *c* according to the load and normal frequency. At the same time restoring is produced through the slider *f*, and the isodrome system *g*, *h*, *i* and *k* by an appropriate change of the value of the adjustable inductance *l*. In this way the adjustment of the regulator in regard to frequency is changed and brought in accordance with the characteristic (relation between frequency and output). The total change of frequency between no load and full load can be adjusted to a value between 0 and 8 per cent. In the first case (0 per cent.), the machine controls the frequency of the system. In order to avoid the occurrance of oscillations, an oil damper *i* is inserted between the servomotor *d* and the inductance *l*, which produces a temporary static adjustable up to 20 per cent. The small motors *q* and *m* provide a remote control of the governor. By the motor *q* a translation of the characteristic of the regulator may be produced by a change of the position of the shaft of the frequency measuring system. By the motor *m*, which controls the adjustable inductance *l*, the adjustment of normal frequency may be changed.

The degree of sensitiveness of the new frequency regulator amounts to 0.03 per cent. Nothing is said about the accuracy, which depends on the influence of temperature, voltage and harmonics on the measuring system. The new governor may be used together with a load regulator. Its application is restricted at present to water turbines.

FATIGUE TESTS BY MEANS OF VIBRATORS.

By Dr. Ing. S. Berg. (From *Zeitschrift des V.D.I.*, Vol. 85, No. 27, July, 1941, pp. 605–608).

The fatigue strength of materials and structural parts can be determined from vibrations by exciting the test piece by unbalances to resonant vibrations.

With vibrators of small weight and minimum space requirements, large forces and moments can be produced at high frequencies of loadings. In the following three types of indirectly acting vibrators will be described.

The Rigid-Pendulum Vibrator.

This vibrator was first used by the Institute for Material Testing at the Technical College, Darmstadt. The vibrator is attached to the test piece by means of a rigid pendulum rod, which is hinged to the test piece. The pendulum rod and the vibrator form a system of low natural frequency. When excited by the much higher natural frequency of the test piece, the vibrator-pendulum system, being above its critical range, deflects within very small amplitudes in a direction perpendicular to the pendulum axis. The component of the exciting forces acting in this direction is, at any instant, counteracted by the accelerating forces of the vibrator casing, whilst the component in the direction of the pendulum axis acts unhindered on the test piece.

A weak spot of the pendulum vibrator is the hinge, which, taking the shape of either a ball bearing or a journal bearing, is rather large in the former, and difficult to lubricate in the latter case.

The Spring-Pendulum Vibrator.

The above drawbacks can be eliminated by inclusion of a leaf spring (*b*), in Fig. 1, between test piece and vibrator (*a*). Then, the leaf spring acts as a cantilever, loaded at the free end by the vibrator. The frequency of torsional vibration of the spring pendulum is kept below the flexural frequency of the main system by utilising the Moment of Inertia of the flat iron weights (*c*).

The Coupling Spring Vibrator.

Sometimes it is required to induce the test piece to such vibrations as are caused by massless forces, *e.g.*, electric forces or gas pressure. This can be done by interposing a coupling spring which is very flexible in the direction of induction. In Fig. 2 the massless induction of the sheet plate (*a*) is being effected by the coupling spring (*c*) which is between the plate and the unbalanced vibrator (*b*) of a definite mass. Thus, the distribution of the moment along the span is sinusoidal, whilst with a directly applied vibrator it would be nearly linear. Another example of the coupling spring vibrator is shown in Fig. 3. The rupture due to fatigue occurs at the blade root. When the vibrator is applied directly, this point moves outwards.

Further possible uses of the coupling spring vibrator with non-harmonic systems are shown in Figs. 4–6. (Suggested by Dipl. Ing. Bernhard, V.D.I.).

Fig. 4 is the test arrangment for torsional vibration on two cardan joints (*a*), of different design whose fatigue strength is to be ascertained. Because of the backlash in the joints, resonant vibration could not be achieved.

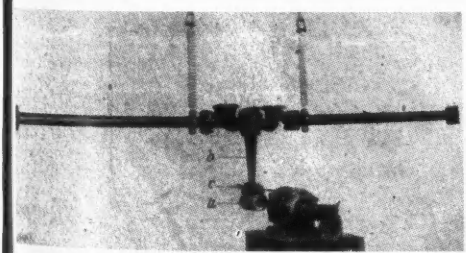


Fig. 1. Comparative flexural vibration test of a cast and welded valve case.

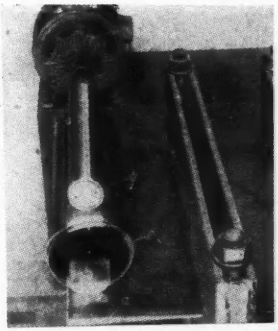


Fig 2. Vibration test of a sheet, one end of which is clamped.

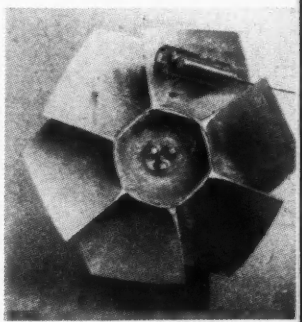
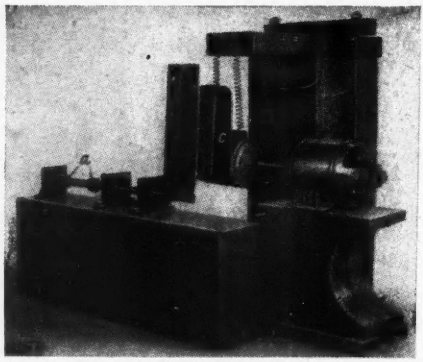


Fig 3. Flexural vibration test of a fan rotor.



The restoring force, lacking owing to the backlash, has to be added. This is shown in Fig. 5, where the spring (*b*) is attached to a fixed mass. Still better results can be obtained when this spring takes the function of a coupling spring (*c*) and is (as in Figs 4 and 6) attached to the vibrator and not to the fixed mass.

Suppression of Undesired Vibrations.

Resonance tests are sometimes made difficult when other undesired frequencies are encountered near the frequency to be excited. For the suppression of these, two methods are available: the separation of the resonances and the removal by means of tuned systems.

Separation of the Resonances.

Tests on torsional vibration of crankshafts require large moments of inertia, realized by levers on each side of the crank (Fig. 7) which are subject to undesired flexural vibration. The frequency of the latter can be lowered below that of the torsional vibration by application of a needle bearing (shown by arrow in Fig. 7) between the crank web and the I-beam.

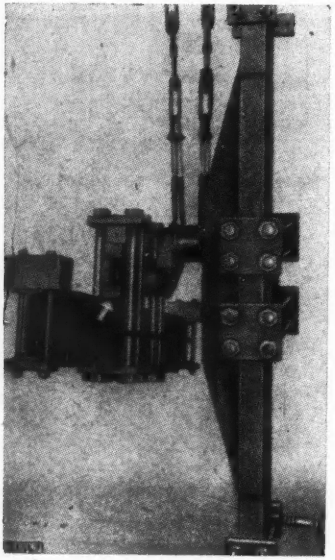
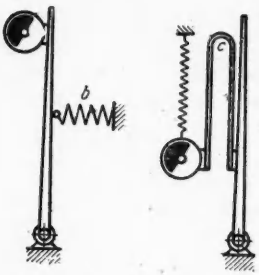


Fig. 7
Torsional vibration test of a crank-shaft.

Another example of separation of resonances has been given in Fig. 1, where the flat irons (*c*) lowered the frequency of torsional vibration below that of the flexural vibration.

Elimination by Means of Tuned Systems.

This often applied method makes use of the double pendulum. The vibration of the primary system



Figs. 4-6. Comparative torsional vibration test of cardan joints *a*.

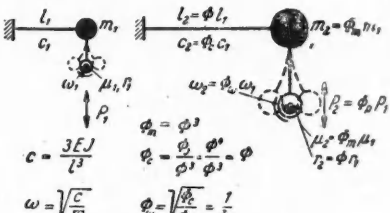
vanish when tuned with a secondary system of a natural frequency equal to the frequency of the primary system. The vibration of the secondary system remain within allowable limits.

To apply this method to the arrangement in Fig. 7, an exactly tuned spring pendulum would be attached to each end of the I-beam.

Standardization of Testing

Vibrator Standardization: In order to test structural parts of all sizes with a minimum number of vibrators, it is suggested to grade the size of vibrators in geometrical order. The "Standard Numbers" according to DIN 323 offer special advantages.

If the smallest system to be tested is denoted by index 1, Fig. 8, and the largest by index 2, Fig. 9, and assuming geometrical similarity of both systems and their vibrators, then according to the laws of similarity derived in Figs. 8 and 9, both systems are equally stressed when working at their respective resonant speeds The ratio of the exciting forces of the vibrators is equal to that of the squares of the vibrator dimensions. The resonant speeds and maximum speeds are inversely proportional to the lengths, and the weights as the third powers of the lengths.



For n steps $\varphi = \varphi^{n-1}$, $\varphi = 3{,}15$ $n = 6$ $\varphi = 1{,}25$

Vibrator Nr.		1	2	3	4	5	6
$\varphi = 1{,}25$	l mm	100	125	160	200	250	315
$\varphi_\rho = 1{,}6$	P_{max} kg	400	630	1000	1600	2500	4000
$\varphi_\omega = 0{,}8$	n_{max} min^{-1}	16000	12500	10000	8000	6300	5000
$\varphi_m = 2$	$G_{Vibr.}$ kg	0,125	0,25	0,5	1	2	4

Figs. 8 and 9.

Assuming the ratio of the smallest to the largest of the structural parts to be tested to be $\Theta = 1/3.15$, and this range be covered by $n = 6$ vibrators. The stepping in the length of the vibrators is then $\varphi = \sqrt[5]{\Theta} = 1.25$, the stepping to the maximum exciting forces $\varphi_P = 1.25^2 = 1.6$, and the stepping of the speeds $\varphi\omega = \frac{1}{\varphi} = 0.8$. The result for all six vibrators is tabulated in Figs. 8 and 9. The stepping of weights is given by $\varphi_n = 1.25^3 = 2$.

Standardization of Gears: To drive the vibrators at various speeds the electro motor must be geared so that

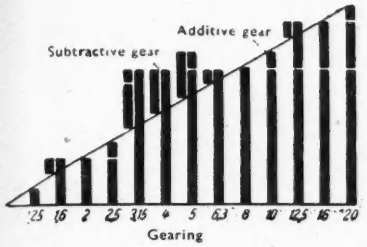


Fig. 10

fine variations according to standard numbers can be made. Fig. 10 shows how a continuous stepping of speed can be achieved with only three gears which are used additively or subtractively.

Standardization of Pendulum Springs: Pendulum springs with spring constants according to standard numbers are shown in Figs. 11 to 13. As the natural frequency of the vibrator must essentially be below that of the test piece, the spring constant of the pendulum spring is of great importance. It is not sufficient to keep it low; the spring must be guarded against destruction through resonance by easy variation of the spring constant. Fig. 11 shows two pendulum springs of different thickness. One end of the rod-spring is screwed to the test piece, the other attached to the vibrator. The rod-springs are slightly conical, and their cross-section is shown in Fig. 12. The natural

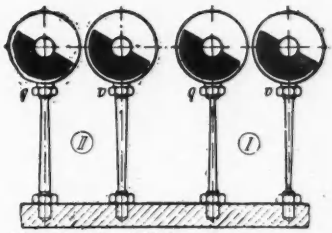


Fig. 11. Possibilities of pendulum-spring installation.

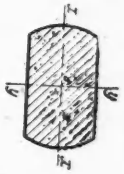


Fig. 12 Cross-section of rod-spring.

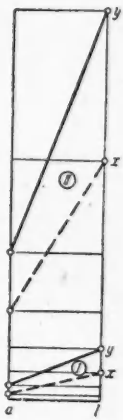


Fig. 13. Spring constants for spring I & II according to different installations.

frequency of the pendulum can be changed by using spring II instead of I, or fixing the vibrator end to the test piece as shown in Fig. 11. Finally, by turning the rod-spring about 90° so that axis x–x in Fig. 12 takes the position of the y–y axis, thus changing the flexural axis. These changes of installation provide eight geometrically stepped spring constants as shown in Fig. 13.

THE ECONOMIC LIFE OF INCANDESCENT LAMPS.

By H. LAURICK, Berlin. (From *Elektrotechnische Zeitschrift* [ETZ], Vol. 63, Nos. 11–12, March 28th, 1942, pp. 147–50).

THE luminous flux of an incandescent lamp decreases during its life. The filament becomes thinner by evaporation, its resistance increases. In consequence, the current, the energy consumption and the luminous flux per Watt decrease. This has to be taken into consideration when calculating the economic life of incandescent lamps, together with the prices of the lamps and of the electric energy and the expenses caused by the necessary replacement of the bulbs.

A Dutch committee has developed, in 1932, the following formula for the calculation of the most economic duration of the life (h_w) of incandescent lamps :—

$$h_w = (4{,}000 \frac{A + B}{s.c})^{0.8} \text{ hours}$$

where

A the price of a lamp in Reichsmark (RM).
B the cost of the replacement of a lamp in RM.
s the price of the electric energy in RM/kWh.
c a constant which depends on the luminous flux.

This formula, which is based on the results of thorough tests, may be still used at present, as the method of manufacture of the lamps has not been changed since then. But the price of the kWh has been lowered considerably during the last decade, and most of the power companies have introduced a two-part tariff with a low running charge per kWh, not only for large power consumers, but also for small residential consumers. Fig. 1 gives the duration of economic life of incandescent lamps (ordinates) which results from the formula for various prices of the kWh (in Reichspfennig) and for various sizes (watt consumption) of the lamps. Lamp prices of April, 1941, have been used for the calculation. This figure shows, that the life of 1 000 hours, which is usual at present, does not correspond to the conditions generally prevailing nowadays.

This result of Fig. 1 is substantiated by the following consideration, which uses another starting point. It is generally recommended to use in a 220 volt-distributing system lamps rated for the normal voltage of the system, *i.e.*, 220 volt. However, it will be shown in the following that it is generally more economical to use instead of 220 volt-lamps such for 230 volt. When incandescent lamps are fed with a voltage lower than the rated

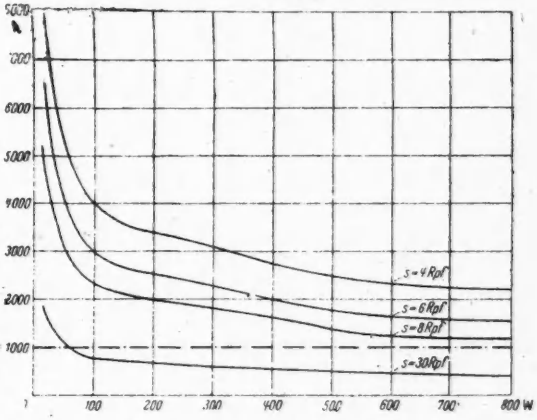


Fig. 1. The economic life of the incandescent lamp.

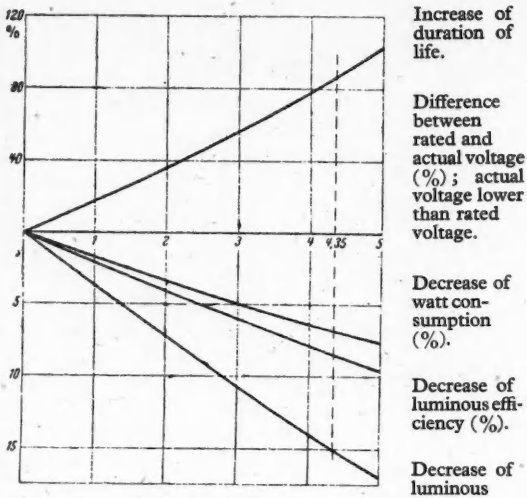


Fig. 2. Characteristics of an incandescent lamp fed with a lower than the rated voltage.

voltage, their characteristic values change according to Fig. 2. When a 230 volt-lamp is fed with 220 volt, that is with a voltage 4.35 per cent lower than the rated, the mean life of the lamp increases from 1,000 to 1,860 hours, the energy consumption, the luminous flux and the luminous efficiency decrease. But it depends on the cost of a lumen per hour, whether 220 volt-lamps or 230 volt-lamps are more economical in a 220 volt-distribution.

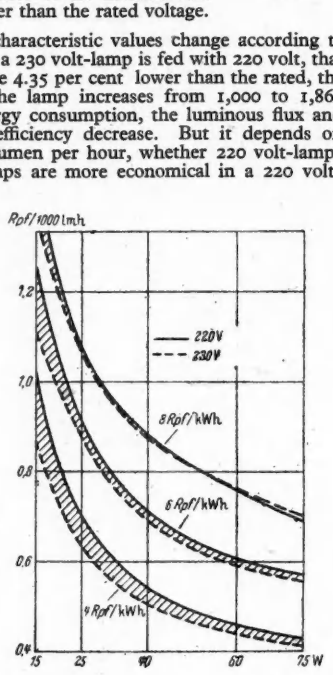


Fig. 3. Decrease of costs when residential consumers use 230 volt lamps.

Calculations have been made for the following three classes of consumers :—

(1) Domestic consumers, which pay list prices when purchasing lamps, but have no expense for the replacement of bulbs ;

(2) Small commercial and industrial consumers, which pay list prices for the lamps, but have some expenses for the replacements of the lamps (RM 0.45) ;

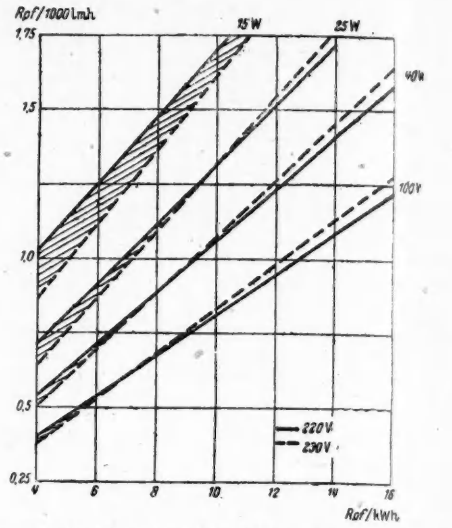


Fig. 4. Savings by residential consumers using 230 volt lamps.

(3) Large factories, which have a consumption of 1,600 lamps per year. Therefore a rebate of 16.6 per cent. will be granted to them. The expenses for the replacement of lamps are assumed to amount to RM 0.45.

The mean consumption of a 230 volt-lamp fed with 220 volt during life duration is 0.98 of the initial energy consumption, and the mean luminous flux is 0.925 of the initial flux.

The result of these calculations are shown in Figs. 3–6. Fig. 3 shows the economy in the cost of 1,000 lumen-

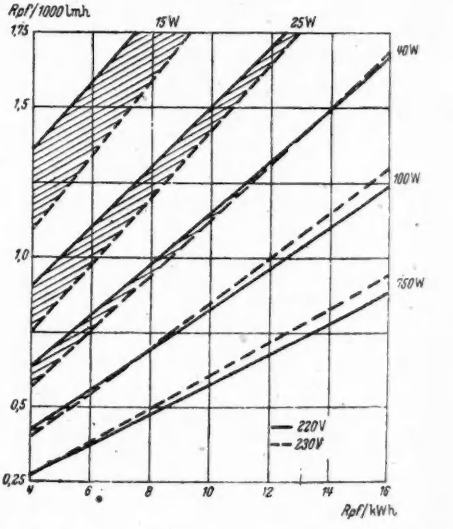


Fig. 5. Savings by small commercial and industrial consumers using 230 volt lamps.

hours with energy costs of 4, 6 and 8 Rpf/kWh. The full line gives the values for 220 volt-lamps on 220 volt, the dotted line for 230 volt-lamps on 220 volt. The abscissae give the watt-consumption of the lamps. Figs. 4, 5 and 6 show what can be saved per 1,000 lmh. by the use of 230 volt-lamps. In these diagrams the abscissae give the price per kWh, and the figures attached to the curves the watt-consumption of the lamps. The formula used for the calculations of the cost per 1,000 lmh. is given in the appendix.

These calculations show that economies result from the use of 230 volt-lamps instead of 220 volt-lamps in a 220 volt supply. Of course, another way to achieve such economies is to manufacture the 220 volt-lamps for a longer duration of life than usual at present. From the curves (Fig. 1) and from the calculations it follows that the present practice of giving to all sizes of lamps the same life is wrong. It can be seen that it is more economical to manufacture the lamps with low consumption with longer life than the lamps of high watt consumption. The author recommends to manufacture lamps up to 75 watt for a life of 2,500 hours, lamps from 100 to 200 watt for a life of 2,000 hours, and lamps over 200 watt for a life of 1,000 hours.

The author supports his proposal by arguing that by raising the life of the incandescent lamps according to this proposal the annual consumption of lamps would decrease to less than half of the present consumption. Several thousand workers would become disposable for other work, and considerable quantities of precious metals (Tungsten) could be saved. In 1937–38 113 million lamps have been manufactured in Germany, but the export amounted to only 15 million lamps. The output of the existing factories, which would become disposable, could be used after the war for a greater export, as soon as the existing international agreements have been annuled or altered. The total load of the German utilities would be influenced by the proposed change of the characteristics of the incandescent lamps as follows :—

Increase of peak load, approximately 5 per cent.
Increase of annual output, approximately 1.2 per cent.

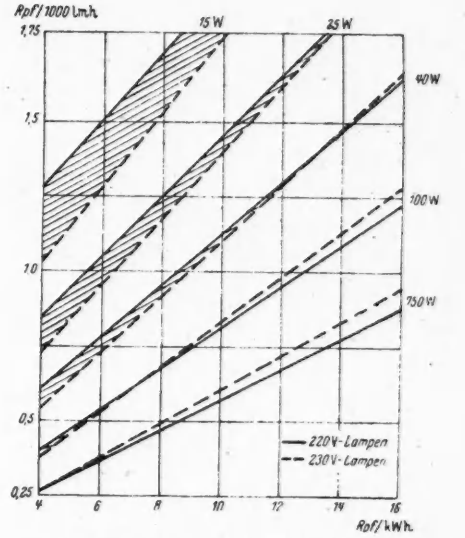


Fig. 6. Savings by great industrial consumers using 230 volt lamps.

APPENDIX.

N Initial consumption of lamp, kW.
N_d Mean consumption during life, kW.
lm Initial luminous flux, lm.
lm_d Mean lum. flux during life, lm.
h Duration of life, hour.
s Price of one kWh, Rpf/kWh.
A Price of the lamp, Rpf.
B Expenses for replacement, Rpf.
K_d Mean cost of 1,000 lmh. during total life Rpf/1,000 lmh.
p Rebate on lamp price, per cent.
Index n Voltage of supply equal to rated voltage.
Index l 230 volt-lamps used for 220 volt-distribution.

$h_l = 1.86\ h_n$ $\quad lm_{nd} = 0.925\ lm_n$
$N_l = 0.93\ N_n$ $\quad lm_{ld} = 0.84\ lm_{nd}$
$N_{ld} = 0.98\ N_l$ $\quad lm_{ld} = 0.84—0.925\ lm_n$
$N_{ld} = 0.98—0.93\ N_n$

$$K_{nd} = \frac{(N_{nd}\, h_n\, s + A\,(1 - \frac{p}{100}) + B)\ 1{,}000}{lm_{nd}\ h_n}$$

$$K_{ld} = \frac{(N_{ld}\, h_l\, s + A\,(1 - \frac{p}{100}\ p) + B)\ 1{,}000}{lm_{ld}\ h_l}$$

PISTON DESIGN FOR LONGER ENDURANCE

By Dr. Ing. F. Gosslau. (From ATZ, *Automobiltechnische Zeitschrift*, Vol. 21, No. 24, Dec., 1941, pp. 613–617.)

In many applications with unfavourable loading conditions, such as in aero engines, etc., the duration of reliable engine performance is limited by the endurance strength of the piston and piston rings.

Although the direct cause of piston ring gumming and sticking is not yet known, there is no doubt about it that the high working temperature existing in the cylinder is responsible for it, and also for a relaxation of the piston ring pressure.

To investigate the influence of temperature upon the lubricating oil a light metal bar was heated at one end, and the used oil from an engine was allowed to drip on the bar along its whole length. The temperature of the bar varied, of course, from a maximum at the heated end to a minimum at the free end. It was found that the residue, adhering to the bar, is more persistent with increasing temperature, while it is harmless below 150° C. It appears from this that by reducing the temperature sufficiently, sticking of the piston rings could be prevented.

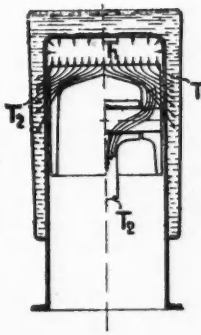


Fig. 1

Heat Flow in the Piston

In 1922 Professor Becker has originated the schematic diagram, Fig. 1, showing the heat flow in "light metal" pistons. According to the Professor: "Since the heat absorbing surface of the piston head increases as the square of the diameter while the circular cross-section of the path of heat flow is only linearly related to it, the thickness

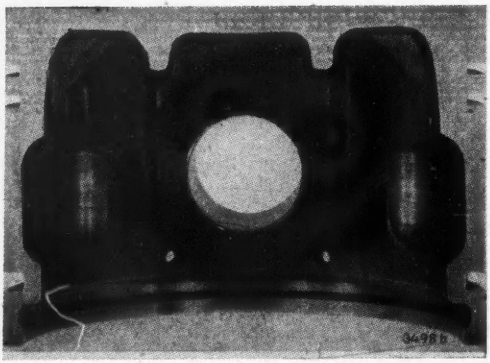


Fig. 2

of the piston head must be increased from the centre towards the outer perimeter. . . ."

An examination of light metal pistons in use to-day would probably reveal that the construction is still based, principally, on the above suggestion. But it appears pertinent to examine whether the aim of the aluminium piston construction in 1922 was the same as the requirement of modern aero-engine construction.

To this end the following three points should be considered :—

(i) When in 1922 aluminium pistons were about to be introduced, the cast-iron pistons, then in use, were prone to strong overheating at the centre.

(ii) Gumming and sticking of the piston rings did not have serious consequences in those days in view of the low engine speeds and loads.

(iii) The main object of the use of aluminium piston was to eliminate the hot central part and to obtain, in this way, a more effective sealing of the cylinder.

As mentioned before a further development of aero-engine pistons, by increasing their endurance strength, is possible only if the ring temperature could be reduced. For this reason a revision of Becker's diagram is necessary and some method had to be devised to determine actual heat flow in pistons.

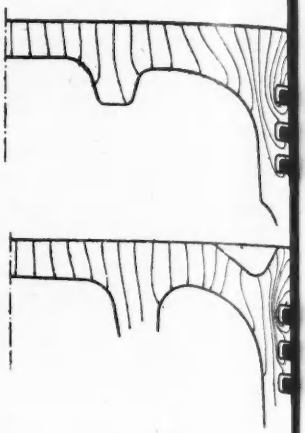
(a) Method of Measurements

Numerous experiments have been devised to measure the temperature at various points in the piston. A great weakness of these tests is that only very few points can be used for temperature measurements and the accuracy is poor.

The search for a better method was based on the idea that a chart showing the isothermal lines in the piston section would also give indication as to the direction of heat flow. In Fig. 2, a piston section is shown, for which the isothermal lines were established. The temperature at various points was determined by hardness testing as can be seen from the impression marks all along the section. This method (of which more details are given below) can be applied not only to the top of the piston, but also to the sides and the section, and gives indication as to the path of heat from piston head to coolant.

(b) Results of Measurements

The important discovery made from the result of such temperature measurements was that Becker's representation of heat flow is hardly justifiable, especially for the centre part of the piston. The isothermal lines (Figs. 3 and 4) clearly show that there is no tendency



Figs. 3 and 4

for the heat to flow to the piston rings from the centre of the piston, but it passes through the piston to the coolant along the shortest route. From the outer part of the piston top, however, the heat flows to the rings which have to deal with considerable heat quantities.

It can be also observed from Fig. 4, that the heat flows generally to the under side of the piston rings. This question was further investigated by examining a section through the piston ring and groove (Fig. 5). It was found that impurities deposit only above and behind the rings, the lower side being in clean contact with the

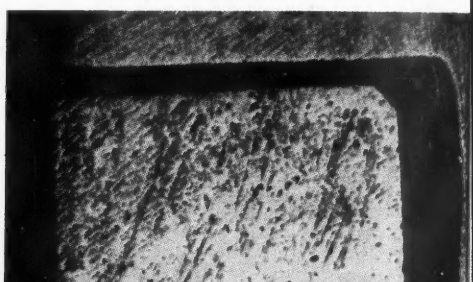


Fig. 5

piston. From this might be concluded that the gas pressure forces the ring against the lower bearing surface and the heat is thus forced to flow round the groove to its underside. To reduce the heat quantity flowing to the rings, the upper ring was lowered in position; moreover a number of cooling finns were provided as shown by the dotted line in Fig. 6. The finns are closely located to prevent high temperatures in the zones between the finns. The outer part of the piston was, contrary to Becker's suggestion of thinner section than the centre (Fig. 6).

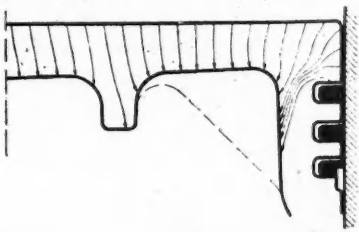


Fig. 6

A piston designed according to the above principles was fitted into an engine and run under severe thermal conditions. Fig. 6 shows the actual isothermal lines as was determined after the test. Although a great part of the heat is flowing right through the centre part of the piston to the coolant, a strong concentration of lines is noticeable at the outer side of the piston too. To bring the coolant even nearer to this locality, holes were drilled between the finns, as shown in Fig. 7. This solution also has the advantage that it reduces the heat quantity reaching the piston rings. Fig. 7 shows the test results with this type of piston.

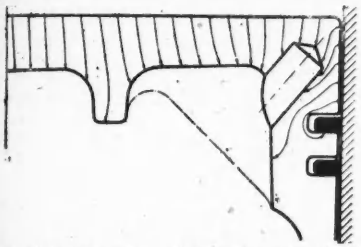


Fig. 7

It is objected against this design that the lubricant cooler must be made considerably larger. This, however, is not the case in practice, as with the more effective cooling obtained it is not necessary to "flood" the whole of the engine with cooling oil. The reduced quantity of oil which has to be circulated only compensates for the improved oil heat transfer, and there is no need for a larger cooler.

Finally, some numerical data are given: By arranging the finns closely to one another and drilling holes (Fig. 7) the effective cooling surface can be made about 2½ times the heat absorbing surface of the piston head, and about 3½ times that of the outer ring of the piston where large heat quantities pass through. The difference in temperature between piston head and piston ring groove is thus increased from 40° to 70° C.

In a 40 H.P./*l* engine fitted with a standard type of piston and using a fuel of octane No. 87, sticking of the piston occurred after 100 hours of running. With the new type of piston, however, sticking did not occur after:—

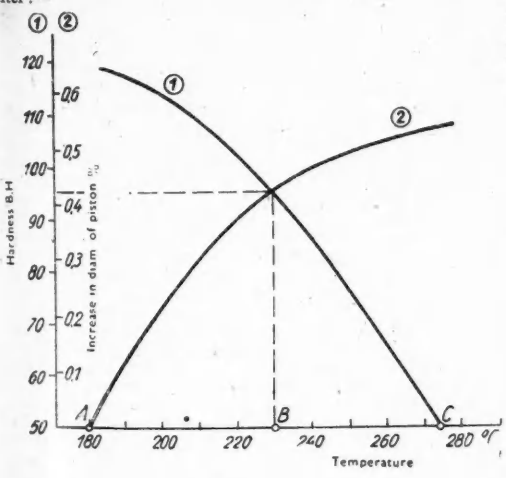


Fig. 8

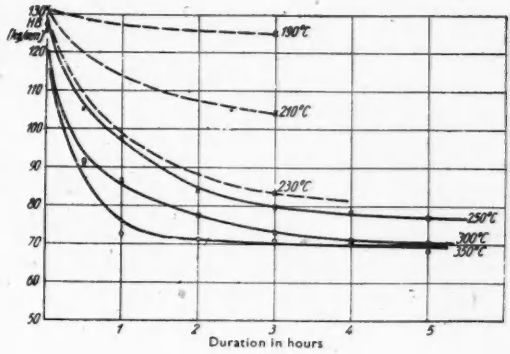


Fig. 9

1. 100 hours in a 40 H.P./*l* engine.
2. 100 hours in a 45 H.P./*l* engine.
3. 110 hours in a 45 H.P./*l* engine.
4. 65 hours in a 50 H.P./*l* engine.
5. 25 hours in a 52 H.P./*l* engine.

Finally, the test was carried on for 500 hours in a 40 H.P./*l* engine at the end of which satisfactory operation was still observed.

Determination of Piston Temperature by Hardness Testing

As further explanation, the heat treatment and the crystalline structure thus produced in the piston is described. After forging the pistons, made of E.C. 124, they are subject to a heat treatment of about 6–8 hours duration at 500° C. This will bring the Cu, Ni, Mg, crystals into solution and a subsequent quenching in water at 80° C. produces an unstable structure. The Brinell Hardness is now about 50 B.h. If now the piston is annealed at 180° C., a part of the heardening elements separate out in a finely distributed state and is responsible for the hardness (130 B.h.) at Point A in Fig. 8. Annealing for a longer period increases the separation of crystalls, but the hardness decreases as shown by the curve 1, in Fig. 8. Simultaneously the volume of the piston increases as shown by curve 2. B. and C. are two other points in the annealing curve, of Which B. is more favourable, as it corresponds to a more suitable compromise between hardness and change in volume. This separation out of crystalls (and the

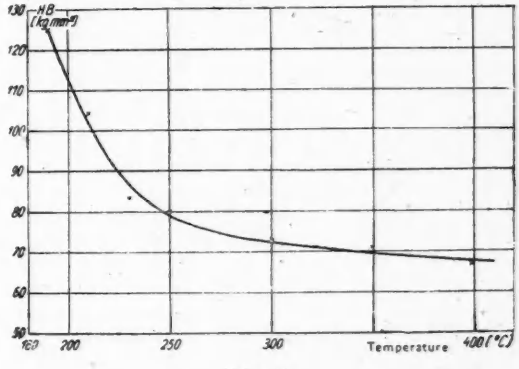


Fig. 10

corresponding hardness) does not, however, depend solely on the temperature of treatment, but also on its duration (*e.g.*, for quenching: time $\longrightarrow$ 0, separation $\longrightarrow$ 0).

The relation between Brinell Hardness and the two variables (temperature and duration) is shown graphically in Fig. 9, for the working material E.C. 124. As can be seen in each case the hardness is decreasing at a rate depending on the temperature, and after about 3 hours is reaching a minimum value. It was also found that the initial condition (hardness) had no appreciable influence upon the hardness after 3 hours. Thus the vertical line through the 3-hour abscissae gives the hardness in dependance of the mean temperature to which it was exposed during the 3 hours. This relationship is more clearly shown in Fig. 10.

Operational Conditions

Before the test, the engine was run for about a quarter of an hour with a rich mixture to warm up the piston and rings. This was followed by a 3-hour test run at full load, the specific fuel consumption being approximately 240 g/H.P.hr. The ignition advance was 25° before D.C. After 3 hours the ignition was disconnected and the piston quickly cooled with a cold blast of air while the shaft was turned round at normal speed. This was done to prevent colder parts of the piston to acquire higher temperature owing to a flow of heat from hotter parts.

The profile of the piston section was then prepared for hardness testing, which was actually performed with a spherical ball (2.5 mm. diam.) tester. The hardness was measured at 2 mms. intervals, closer measurement not being possible without mutual interference of the impression marks and the consequent change of material density (by compression). The test load was 62.5 kg., applied in 10 seconds, and duration of 30 seconds.

SCARFING HIGH CARBON AND ALLOY STEELS.

By G. D. WINLACK. (From *Iron and Steel Engineer*, Vol. 19, No. 4, April, 1942, pp. 26–33).

ALTHOUGH torch deseaming, or "scarfing," was first adopted some fifteen years ago, it has been only in the last few years that its great value to the industry has been fully recognised by practically all steel producers. Partially responsible for this recognition has been the constantly increasing demand for superior steel products produced at higher speeds and lower costs This demand is exemplified by the high quality steel required by the automotive and aircraft industries and the railroads, in which all surface defects of blooms, slabs and billets must be removed at whatever stage of production they appear. To meet these increasingly stringent requirements, a process must be employed that will do this work satisfactorily and with economy, yet not interfere with production schedules. All steel producers fully recognize that the older methods of cleaning steel by hand chipping, machine chipping or swing grinding, are not only exceedingly slow, when considering the tempo of the present-day production units, but also very costly. The storage and re-handling of large stocks of unfinished steel is a great obstacle in the high speed production programme of the mills to-day.

With the newest steel cleaning methods, torch deseaming or scarfing, it is possible to maintain a smooth productive flow without difficulty, and at the same time to conserve space, eliminate much rehandling, lower the production cost and produce a satisfactory product.

Scarfing is a process of burning out defective areas on the surface of semi-finished steel, by the oxyacetylene method. By this means, the surface of the steel is placed in such a condition that it can be rolled or forged to a satisfactory product.

Use of the scarfing process has increased very rapidly during the past few years. Many plants are now scarfing 100 per cent. of all semi-finished products. In fact, the use of scarfing for removal of defects has increased to such an extent that the tonnage now cleaned by this method compares favourably with that of the combined tonnages now cleaned by hand chipping, machine chipping and swing grinding. Large savings in time with large economies are being realized by the plants using the oxyacetylene cleaning process. It is in most cases from 6 to 15 times faster than mechanical chipping, hand chipping or swing grinding.

The value of the scarfing process becomes even more apparent with the increse in the amount of surface cleaning required per ton of steel conditioned.

For a period after its introduction, the scarfing operation was only used as an auxiliary to hand chipping, and on salvage or reclamation work for cleaning of badly cracked ingots, blooms, billets and slabs, which otherwise would be scrapped due to prohibitive cleaning costs. This is not so to-day. Development of deseaming techniques for the various grades of steel in their many sizes and sections, from ingots to 1½ in. square billets, along with many improvements in torches, tips and auxiliary starting equipment, has advanced to a point where to-day, scarfing is being done on practically all grades of steel which oxidize readily under an oxygen stream. Steels now being scarfed include all grades formerly chipped, and a great number of grades formerly swing ground. This includes practically every SAE grade of steel, with the exception of the corrosion and heat resisting steels. Also, a great many special grades of alloy and tool steels not listed on the SAE steel classification, which are generally swing ground, can be and are being cleaned by the oxyacetylene process.

Metallurgy of Scarfing.

The removal of defective surfaces from the higher carbon alloy and tool steels by scarfing involves some metallurgical factors, which, if not taken into consideration, will probably result in failure of the operation. The rapid heating of the steel surface by the oxyacetylene preheating flames and the heat of the oxygen-iron reaction will cause a change in the structure at the surface with resultant varying degrees of hardness and highly localized stresses. The hardness and stresses developed are governed by the analysis of the steel. The same properties are present in the scarfed surface as would be developed by a hardening treatment, since the quenching effect of the cold centre on the hot surface of the steel is even more drastic than quenching in water. A hardened case is formed on the steel surface to approximately 0.15–0.030 in. in depth, depending on the character and analysis of the steel.

It is well known that, when a marked change of hardness is present with accompanying high localized stresses in a piece of steel, there is great danger of cracking the piece. It can readily be understood that such a condition may be present in steel of high hardenability which has been scarfed unless adequate precautions are taken. Lack of consideration of this factor was largely responsible for a great deal of adverse criticism, which was directed against scarfing when the process was first used on alloy and high carbon steels. Since adequate precautions were not taken at first, a great deal of the material was scrapped due to cracking

and the blame categorically fastened upon the scarfing operation.

If the above-mentioned quenching effect of the cold centre of the steel could be rendered less drastic, the marked hardness gradient and high stresses in the steel after scarfing could be materially reduced and the danger of cracking eliminated.

The obvious answer to this problem is preheating the steel before scarfing to cut down the temperature gradient between the scarfed surface and the centre of the steel. The degree of preheating necessary is dependent upon the analysis of the steel and its resultant hardenability.

Preheating and Scarfing Procedures.

Preheating of material to be scarfed is being done in several ways, namely :—

1. Catch the steel at the desired temperature, while it is cooling from a previous operation such as forging or rolling.
2. Place material on piles of hot steel.
3. Soak in hot water, rinse tanks in pickling departments or in hot-water tanks especially built for the purpose with and without automatic temperature controls.
4. Heat in normalizing or annealing furnaces or specially built pit type furnaces.
5. Heat in specially built continuous type furnaces.

Of these preheating methods, item 5 naturally is the most efficient, since it makes possible any temperature of preheating which may be desired, and provides a rapid and economical production operation. In one such installation, now being used, cold blooms and billets are passed through an oil fired heating chamber on an endless chain and are discharged at a temperature which has been found adequate for any of the higher carbon or alloy grades being scarfed. Due to the cost of installation, the continuous type of furnace (item 5) as yet is only used in plants of large production.

Catching the steel in a cooling operation (item 1) is, of course, less satisfactory because of lack of temperature control. Heating in hot water tanks (item 3) has a very limited application because of limitations in temperatures attainable.

In most cases, it will be found that an ordinary bottom-fired pit type furnace (item 4), which is economical to install and operate, will be suitable for preheating of all grades which can be scarfed.

In preheating for scarfing, an adequate factor of safety lies in using a standard preheating temperature which experience has shown will normally cover all conditions tending to make scarfed billets susceptible to rupturing.

From experience, it has been found that, for most steels, preheat temperatures up to 400° F. will be sufficient, provided scarfing operations are started at once and completed without delay. In preheating with low temperature, a simple rule to follow is to allow for heat penetration at the rate of one inch per hour with a minimum of two hours in all cases. This rule was established as a result of a great many studies.

Some mills, for special reasons of their own use a preheat of as high as 700° F. for certain grades of steel. If at all possible, preheat temperatures should be kept under 400° F. for with temperatures higher than this, cleaning of slag from the scarfed surfaces becomes more difficult and efficiency of scarfing operator is reduced due to high heat.

Annealing after rolling will not substitute for preheating before scarfing. It will lessen the tendency towards transverse cracking of the steel, but will not eliminate the " lace curtain " cracks sometimes obtained after scarfing. Preheating is the only known preventive for " lace curtain " effect.

In determining preheat temperatures to be used, it is well to consider certain conditions peculiar to particular operations. These conditions include characteristics of mill heating furnaces, in which steel will be heated for rolling after scarfing and size and length of pieces to be scarfed.

If mill heating conditions are drastic, it is important that a less highly stressed material be charged into the furnace than would be the case if the scarfed material were to be heated gradually. In general, the greater the danger of cracking, the longer the piece being scarfed.

Weather conditions must usually be considered in setting up preheating schedules. A steel which can be successfully scarfed without preheating in warm weather may crack if scarfed without preheating in cold weather. In other words, a steel which can be successfully scarfed with 300° F. of preheat in the summer may require 400° F. in the winter. Winter period is generally considered from November to April inclusive, with modifications to suit the locality.

In scarfing of ingots, the weakness of an " as-cast " structure should always be recognized. Ingots of any grade, and especially of the higher carbons and alloys, should be scarfed at a temperature sufficient to insure against stress relief cracking. The proper handling procedure for this type of material can be gauged by the analysis.

For checking the temperature of preheated steel at the scarfing beds, it is well that the inspector or some other person in charge, be supplied with contact thermocouples, temperature pills or alloy sticks. Any material which falls below the required temperature should be returned to preheating furnace for preheating.

No preheated steel that has been partially scarfed and allowed to cool should be scarfed without reheating again.

Pickling of scarfed steel should be done with caution, inasmuch as the action of the acid will attack the hardened area developing an " alligator hide " type of defect on the highly stressed surface. Some companies have, in their particular cases, found that this is true in the case of carbon steels of 0.50 per cent. carbon and over and alloy steels of 0.40 per cent. carbon and over which have not been preheated prior to scarfing. For this reason, pickling can be used as a check to determine whether or not the steel was properly preheated. Stress-relieved cracks may be developed on the surface of the steel, either from cooling after improper scarfing procedure or on heating up in the rolling mill furnace. The relief cracking is discernable in the roughing line of the mill appearing as cross checking, and will carry through to the finished size in defects generally known as " crows feet." This condition can be only eliminated by preheating before scarfing.

The partly oxidized material, commonly known as fin, if remaining on the billet after scarfing will carry through to the finished product and appear as scabs and slivers unless the rolling mill furnace has the ability to scale it off. This is often the case in the rolling of certain alloys where rolling temperature is kept low in order to hold decarburization to a minimum. When this is the case, care must be taken in scarfing to insure a minimum of fin. Types of steel having high percentages of nickel, molybdenum and copper are very susceptible to finning, especially in the low carbon ranges, since these elements resist oxidation. A good operator, by using proper torch technique, equipment and fuel pressures, can scarf almost any steel and leave practically no fin. In certain mills, due to heating and

rolling limitations, it is necessary to remove fin if any is produced.

All the aforementioned factors must be taken into consideration, and if applied to each mill individually, will insure first class surfaces on the finished products.

In some mills, a combination of lack of familiarity with the process, the usual resistance accorded a new procedure and either the lack of time or the unwillingness to make proper investigation has resulted in a tendency to attribute any defective surface on a finished product to the fact that the semi-finished material was scarfed. It may be well to point out, in view of the marked success attained in scarfing of high carbon and alloy steels, that before a defective surface on a finished product is attributed to scarfing, it is advisable to investigate all phases of the manufacturing procedure.

Advantages of the Oxyacetylene Process.

Torch deseaming, or scarfing, of high carbon and alloy steels offers the following advantages :—

1. It is several times faster than mechanical chipping, hand chipping or swing grinding, with increased production at the rate of approximately 6, 8 and 15 times respectively, having been obtained.

2. It offers the opportunity for large savings in conditioning costs over any other cleaning method.

3. It enables salvaging of much material which formerly had to be scrapped due to prohibitive cleaning costs.

4. It presents facilities to condition blooms, bars, billets and slabs, so as to insure perfect quality of surface when the steel is reworked to finished products.

5. It makes possible a reduction in inventory, stock and handling facilities.

6. It provides a reduction in delays in assembling stock for rolling mill schedules, thus expediting shipments to customers.

FIRE EXTINGUISHERS IN HIGH TENSION PLANTS.

(Communication from the *Physikalisch-Technische Reichsanstalt.*) By K. H. STRAUSS, Berlin. (From *Elektrotechnische Zeitschrift* [ETZ], Vol. 63, Nos. 9–10, March 12th, 1942, pp. 117–8).

IF an unsuitable extinguisher is used in a high tension plant and live parts of the plant are sprinkled, a current may flow through the jet and the body of the operator giving him a shock which may be dangerous. Furthermore, flash-overs damaging the plant seriously may occur in consequence of sprinkling insulating parts with the extinguishing medium. Therefore, two demands have to be fulfilled by fire-extinguishers, which are used in high-tension plants :

(*a*) The capacitance current, which flows from a live part of the installation through the hand fire-extinguisher to earth, should not change considerably when the extinguisher is applied. When the jet of an extinguisher is directed from about 1 m. distance against a metal plate carrying 130 kV. a.c. to earth 50 cycles, the capacity charging current amounts to approximately 0.1 to 0.3 mA.*

(*b*) A bus insulator, carrying 90 per cent of its dry arc-over voltage shall not arc-over, when sprinkled with the extinguisher medium, either during the application of the extinguisher or afterwards. The value of the voltage has been fixed with 90 per cent, as the arc-over voltage should not be lowered considerably by the sprinkling with the extinguisher liquid.

A. Burmeister (*Physikalisch-Technische Reichsanstalt*) recommended, in 1926, that extinguishers be tested according to Fig. 1, using a sensitive galvanometer, which is suitable for measuring the current, especially the peak values occurring when bridges are formed in the jet.

The extinguishing media of various chemical composition, which are used, have been tested. It seemed advisable to report on the suitability of the various extinguishers as far as their use in electric plants is concerned. There exist at present three groups of extinguishers, which use different chemical extinguishing media :

1. Extinguishers using dry media in powder form, *e.g.*, Carbondioxide Dry-Extinguishers.
2. Extinguishers using a liquid chemical medium, *e.g.*, CCl_4 or other halogenated hydrocarbons (Carbon-Tetrachloride and Methylbromide Extinguishers).
3. Foam Extinguishers using water and foam producing chemicals.

1. Dry Extinguishers.

A current of 0.2 to 0.3 mA flows through the jet of a dry extinguisher using a $NaHCO_3$ and talc powder, when it is directed against a metal plate in 1 m. distance, carrying 130 kV. The current does not attain appreciable higher values, when the apparatus is operated. No arc-over occurs, when it is directed on an insulator. Therefore, extinguishers of this design are suitable for the use in high-tension plants.

2. Tetrachloride and Methylbromide Extinguishers.

The Tetrachloride extinguisher using an extinguishing medium consisting mainly of CCl_4 and the extinguishers, the liquid of which consists of Methyl- and Ethyl bromide, produce scarcely measurable currents when used as described above. Therefore, there exists no danger for the operator. But an arc-over occurs on a live insulator if a jet of an extinguisher medium containing 50 per cent Methylbromide and 50 per cent. Ethylbromide is directed on it. Some liquids change their colour from colourless into dark brown in consequence of such an arc-over. It seems that the arc causes a chemical decomposition. Probably the arc-

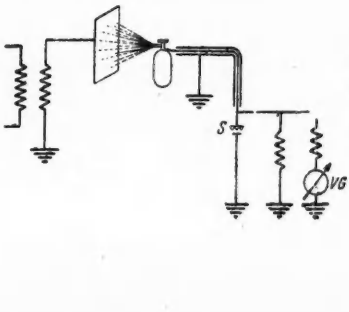


Fig. 1
Arrangement for the measurement of the current in the extinguishing jet.
S spark gap.
VG galvanometer.

* Tests of R. Vieweg, published in *Elektrizitaetswirtschaft*, Vol. 15, 1933, p. 311, showed that for some persons the threshold of perception is at 0.1 mA, but may be in general at 0.3 mA. These low currents involve no danger to the human body.

over starts in consequence of the condensation of the humidity of the air following the sudden cooling of the insulator.

3. Foam Extinguishers.

In these extinguishers a foam producing substance is added to water. The extinguishing liquid is expelled by CO_2 pressure from the spray nozzle in the form of foam. This foam covers the fire and may also cover live parts. The conductivity of the jet depends on the distance of the live conductor from the nozzle, as the formation of bridges, which endanger the operator, decreases in greater distance. Tests have been made with various distances between the nozzle and a metal plate carrying a voltage of 6 kV. The results of these measurements are shown in Fig. 2. The two curves show the lowest and the highest currents. Another extinguisher showed even 11 mA. at 1.75 m. distance and 15 kV.

The risk for the operator increases when the pressure in the extinguisher decreases in consequence of a leakiness of the CO_2 cylinder, as the quality of the foam then becomes poor and the conductivity of the jet increases. Therefore the foam extinguishers are unsuitable for high tension plants in regard to electrotechnical considerations. The origin of the unsatisfactory behaviour is evidently the foam generator, added to the water for the production of the foam. It raises the conductivity of the water from 500 μ S cm^{-1} to 3,000–6,000 μ S cm^{-1} depending on the quantity of the foam generating chemical added to the water.

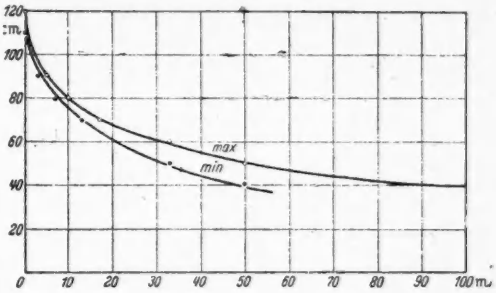


Fig. 2. Results of the measurement of the current between a metal plate and the nozzle of a foam extinguisher. Ordinates: Distance of the nozzle from the plate; Abscissae: Current (mA) produced by a voltage difference of 6 kV from the plate to earth.

Summary.

The tests showed, that the extinguishers using extinguishing media in powder form work satisfactorily in general. Bromide extinguishers cause arc-overs on insulators at 90 per cent rated arc-over voltage, when liquids consisting of 50 per cent Methylbromide and 50 per cent Ethylbromide are used. These extinguishers may occasionally damage the electrical apparatus. The use of the foam extinguishers in high tension switch plants has to be avoided in regard to the high conductivity of the foam jet and the endangering of the operator of the extinguisher.

MEASUREMENT OF DUST IN FLUE GAS.

By Dr. Ing. J. Engel. (From *Die Wärme*, Vol. 64, Nos. 29 and 30, July, 1941, pp. 277–282 and 285–291).

[The correct determination of dust content in flue gases represents a difficult problem, in the elaboration of which Allner, van Tongeren, Zimmermann, Rosin and Kaufmann are claimed to be the pioneers. The present article gives some additional experimental results achieved in the "Technischer Uberwachungs-Verein," Magdeburg.]

In order to measure the dust content, it is common practice to separate a small quantity of the flue gas and pass it through a small filter operating at practically 100 per cent efficiency. The weight of dust collected is then divided by the volume of the gas passed through the filter.

To obtain larger quantities of dust, necessary for the determination of dust particle size, the filter must be placed outside the main gas flow. If, however, the objective is only to determine the combustible content of the dust, a simpler device, with internal dust filter, can be used.

Internal Filter Type

Using an internal filter, the author carried out dust measurements in the flue gas of stoker and pulverized-fuel fired boilers in 1924–25, this being before the date when such tests were systematically performed. The purpose of the test was to determine the heat lost through the heat carried away by the dust particles.

To determine the gas velocity in the main flue, a special "Prandtl" tube was used. The filter material consisted of "Triple Extraction Shells" 5 ins. long and 1¼ ins. diam. (Fig. 1). These could be used up to about 360° F. The filter retained particles down to 2–5 μ.

Satisfactory results could be also obtained by using two filter screens: the inner screen of 178 mesh/lin. in., and the outer one of 328 mesh/lin. in. This filter arrangement could be used also for heat loss determination, since particles smaller than 40 μ which would pass through the finer of the two screens, contain only very little unburnt matter. Such simple filter screens could not be used, however, for pulverised fuel boilers.

In Fig. 1 a paper filter is shown fitted into a tin casing, comprising two parts fitted together by a bayonet catch. A sampling tube is screwed into the cylindrical lower part; the conical upper part carries the filter tube (copper) and a stepped lining to the throat of which the filter is fixed by a length of wire. A cone, fixed to the tube by means of two fins serves a double purpose. It distributes the gas over a wider filter surface and prevents the dust particles, when suction ceases, being carried back into the gas stream.

Naturally, the water vapour in the gas drawn in by the filter must be estimated very accurately. The gas is, therefore, passed through a two-stage condenser, next through two glass cooling coils in parallel connection, and finally through a calcium chloride drying tower.

External Filter Type

External filters, as was pointed out above, are used for investigating the composition of dust, *i.e.*, when greater quantities of dust are needed than can be collected with internal filters.

The BEWAG-Zimmermann measuring apparatus:

Fig. 2 shows diagrammatically the arrangement of the apparatus used for high dew-point gases. The figure is self-explanatory.

An apparatus used by the Thermal Branch, Halle, for measurements when the volumetric flow is less than 525 cu. ft./hr. is shown in Fig. 6. The inclination of

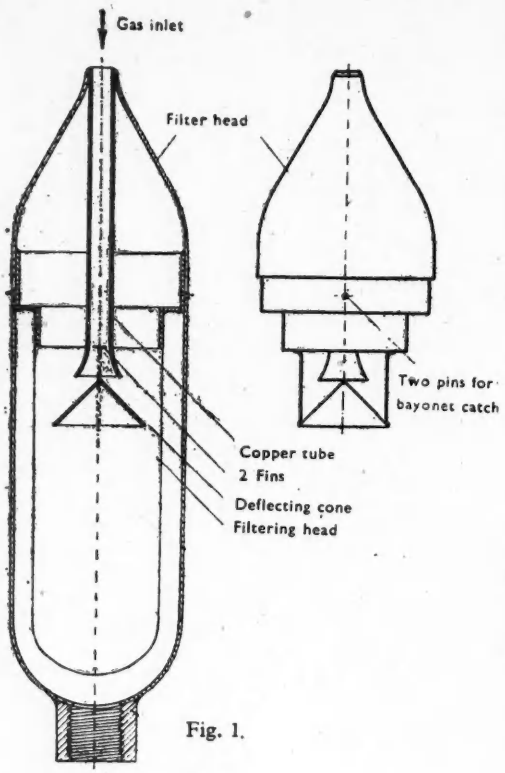


Fig. 1.

the differential pressure gauge is adjusted according to the gas velocity; thus when the gas velocity is 260–350 cu. ft./sec. the inclination of the gauge is 1 : 10 and the variation of gauge reading may be ± 7 mm. alcohol head. If, however, the gas velocity is small, the gauge must be adjusted to greater sensitiveness. From this it follows that at very small gas velocities, measurements by the zero pressure method become unreliable. Lately micromanometers with swinging glass tube are employed in place of the differential gauges. Table I. gives the internal diameters of the sampling nozzles used by the Halle organisation.

TABLE I.—NOZZLE DIMENSIONS (VAN TONGEREN).

Size.	Velocity, ft./sec.	Internal Diameter, ins.
A	10–16.5	1.7/16
B	16.5–25	1.1/8
C	25–33	1
D	0–50	13/16
E	50–66	21/32

A sampling nozzle as shown in Fig. 4 and Fig. 5 illustrates the electrically heated cyclone dust extractor for 525 cu. ft./hr. The sampling nozzle should be parallel to, and facing, the direction of gas flow. In order to eliminate deviation from this position a direction indicator is used. According to Zimmermann, the error is 2 per cent when the deviation of the direction of flow is 10° and 7 per cent when the difference is 30°.

Generally the suction tube should be made as short as possible, as condensation might take place in a long tube, and the dust would reach the cyclon in a muddy state. This must be avoided at all costs, not only because of the possible loss of weight owing to the wet dust

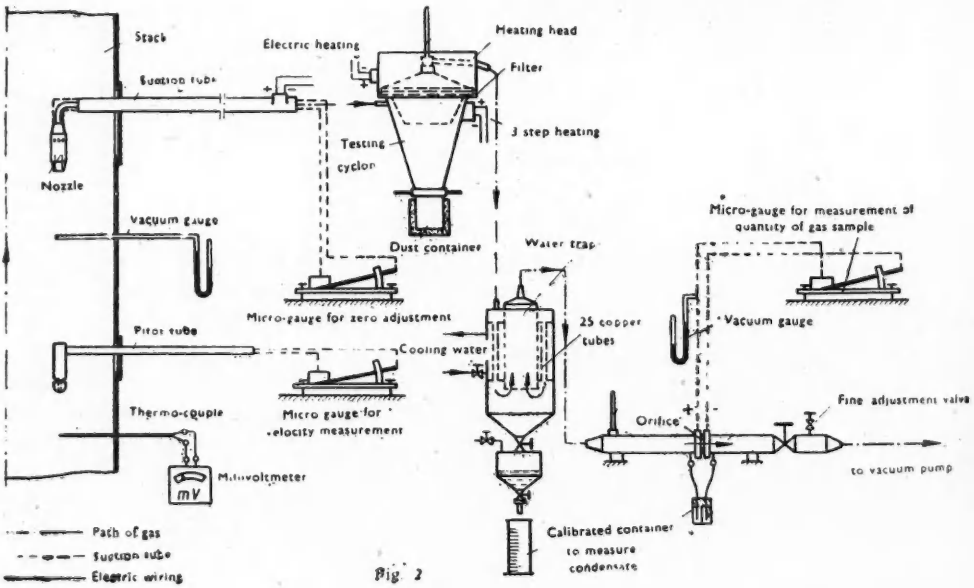


Fig. 2

adhering to the walls, but also because water droplets may cause tearing of the filtering paper, thereby impairing the result of the experiment. A short length of piping with adequate heat insulation, or better still, heating should be used.

If the apparatus is to be used for gases low in temperature and of high dew point, as well as with unavoidably long pipe connections, an efficient water separator after the dust collector is needed and the condensate collected. In the water separator the gas is cooled below its dew point and hence saturated by condensing the surplus water. If no further cooling takes place during the path of the orifice, naturally further condensation will take place, but the quantity of water will be so small that it will suffice to place a small condensate collector under the orifice.

In order to determine whether the whole of the water (originally as steam) present in the gas has been accounted for before the orifice, a heat balance sheet should be prepared taking into account even the small quantity present in the precipitated dust.

To avoid cooling the flue gases below their dew point in order to estimate their water content, the water content of the gases must be calculated from the fuel analysis and the wetness of air supplied. A water separator is needed whenever water content cannot be determined from the coal analysis, and when it is not possible to establish with accuracy the dew point of the flue gases.

The condensate should be removed from the collector vessel from time to time as if it contains dust, there is indication that the filter paper has been pierced. This is also indicated by a sudden drop of the vacuum. Since tearing of the filter usually spoils the experimental results, it is the worst type of break-down for such experiments. If the vacuum pump is powerful enough, therefore, it is advisable to use a double filter paper.

To avoid condensation where water might cause trouble, the metal cover of the cyclone is also heated. The original maximum heating capacity of the apparatus, 450 W., which could be switched on in 3 steps, proved insufficient for low temperature flue gases, and was increased to 800 W. The vacuum pumps are usually electrically driven, since laying of cables is cheaper than erecting pipes for steam or compressed air.

For the collection of larger quantities of dust the 525 cu. ft. capacity apparatus will not suffice. The BEWAG type filters designed for capacities of 1,750 and 3,500 cu. ft./hr. respectively are shown in Figs. 7–8. The filter shown in Fig. 7 has 3 stages, and comprises 6 filters. Fig. 8 shows the cyclon for 3,500 cu. ft./hr.

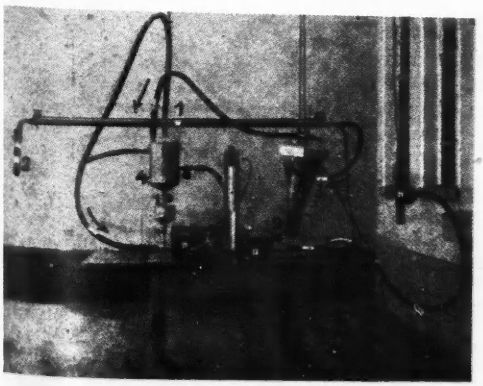
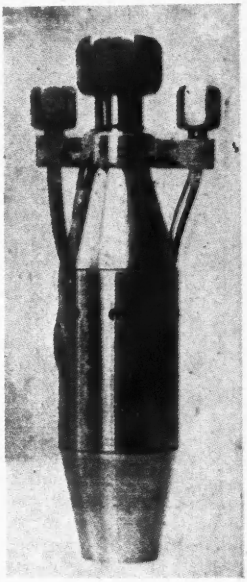


Fig. 3

Fig. 4. Sampling nozzle Type van Tongeren; manufactured by Rosenmüller.



capacity with the heating casing removed. Fig. 9 shows a still larger unit, with a capacity of 21,000 cu. ft./hr. Originally this was used only as a testing model to take dust sample from flues and stacks and to compare results with the performance of large plants in actual service. Later, however, it has been adapted for the purpose of dust measurement.

The Babcock Model

With the zero point measuring method, trouble has been experienced at low gas velocities, *e.g.*, below approximately 10 ft./sec. Using a patented sample nozzle, the latest (German) Babcock device overcomes this difficulty. The arrangement is shown in Fig. 10.

Fig. 11 shows the Babcock apparatus. Owing to the larger capacity, 3,500 cu. ft./hr., two different dust precipitators are arranged. There is, first the smaller centrifugal filter, E, for coarser particles, and then a fine cloth filter, F, to retain the finest dust particles. A part of the dust retained by the cloth filter cannot be removed from the cloth; but this is not so important as the quantity of dust retained which can also be estimated by weighing the filter before and after operation. When particle size is to be determined, there must be some sacrifice of accuracy by using the cloth filter, which is but partly compensated by the progressively improving efficiency of cloth filter with continued usage. When its resistance to flow exceeds a certain limit, it can be easily cleansed by compressed air.

A particularly convenient characteristic of the

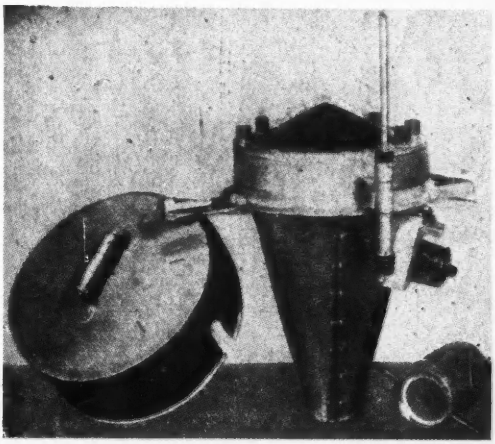


Fig. 5. Bewag-Zimmermann cyclone including a filter for 525 cb. ft./hour, manufactured by Rosenmüller.

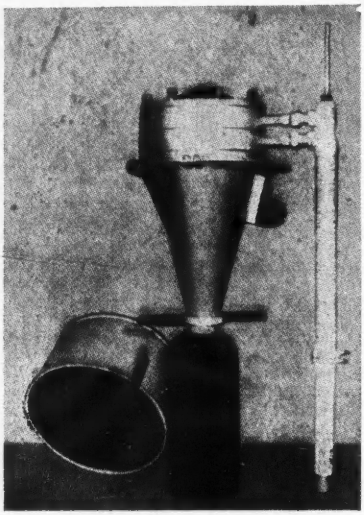


Fig. 6

Bewag-Rosenmüller Double Cyclon with immediately attached vertical measuring gauge, and a particularly large dust collector.

apparatus is that its temperature can be raised sufficiently to eliminate the use of the water condenser. The cyclon is heated to 320° F., and the filtering vessel to 240° F. The temperature is controlled by an electric resistance.

At a temperature of about 165° F. at the orifice, with a normal gas composition and a maximum pressure head of 2 in. w.g., a gas volume of 2,625 cu. ft./hr. passes the orifice which equals about 3,500 cu. ft. at the temperature of the measuring section, *i.e.*, at 355° F.

On the other hand, if the temperature at the orifice is very high, *e.g.*, for gases from cement kilns, the sampling tube must be cooled.

Fig. 12 shows a section of a Babcock nozzle. In Fig. 13 the photographs of two nozzles are shown for 27–38 and 19–27 ft./sec. gas velocity; the diameters are $2\frac{1}{8}$ in. and $2\frac{5}{16}$ in. respectively.

The annular space between the cylinder, 3, and the tube, 2, is connected to the main flue through four slots, 5, so that the static pressure can be transmitted through tube 6, and tube 1, to a pressure gauge. From a second annular space 7, four tubes, 8, lead out with the opening sufficiently removed from the suction section so as not to affect the velocity of flow at the nozzle. Through the tube 9, the total pressure in the main flue is transmitted to the pressure gauge and hence the difference in reading represents the velocity head from which the velocity of flow can be calculated.

If the sampling nozzles were independent of the velocity of flow, a single nozzle would be sufficient. In practice, however, the quantities of gas and dust measured differ considerably according to the velocity of flow. Furthermore, small gas velocities interfere with the satisfactory operation of the cyclone. It is, therefore, customary to have a set of nozzles in reserve to suit test conditions. The "Approved Rules and Standards" for such tests demand that the section of the sampling nozzle be at least 0.05 per cent. of the tested flue section for high dust content or coarse dust particles or for any unusual condition of tested section. For fine dust or smaller dust content the nozzle section may be as low as 0.005 per cent. of the flue section.

For a correct selection of the size of the sampling

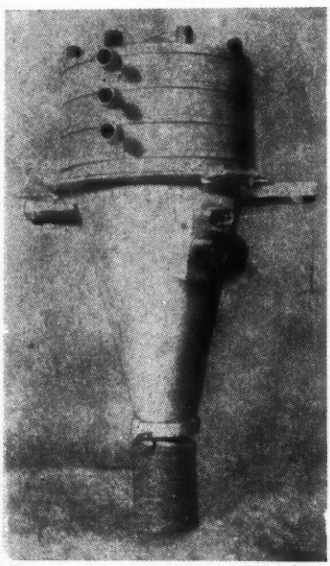


Fig. 7. Threefold Bewag-Rosenmüller measuring cyclone including 6 filters on a moveable stand, for a capacity of 1750 cb. ft./hour.

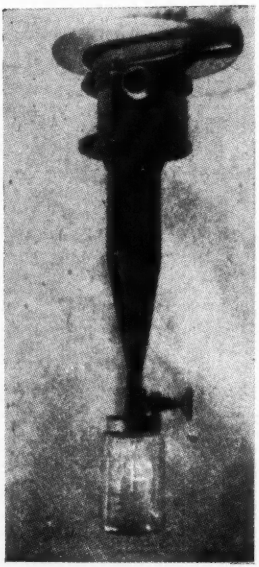


Fig. 8. Rosenmüller measuring cyclone with glass dust collector, 3500 cb. ft./hour, heating dismantled.

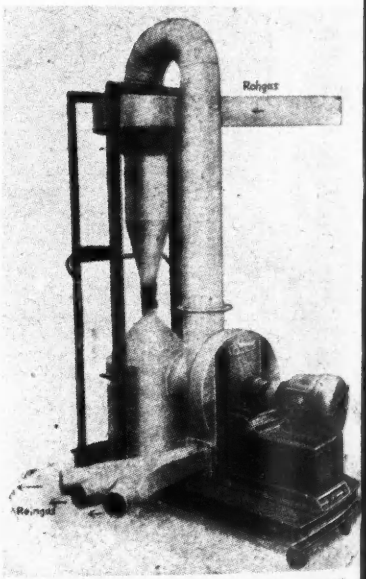


Fig. 9. Dust sampling device "Meteor" manufactured by the Meteor Ventilatoren Akt.-G. for a capacity of 21,000 cb. ft./hour.

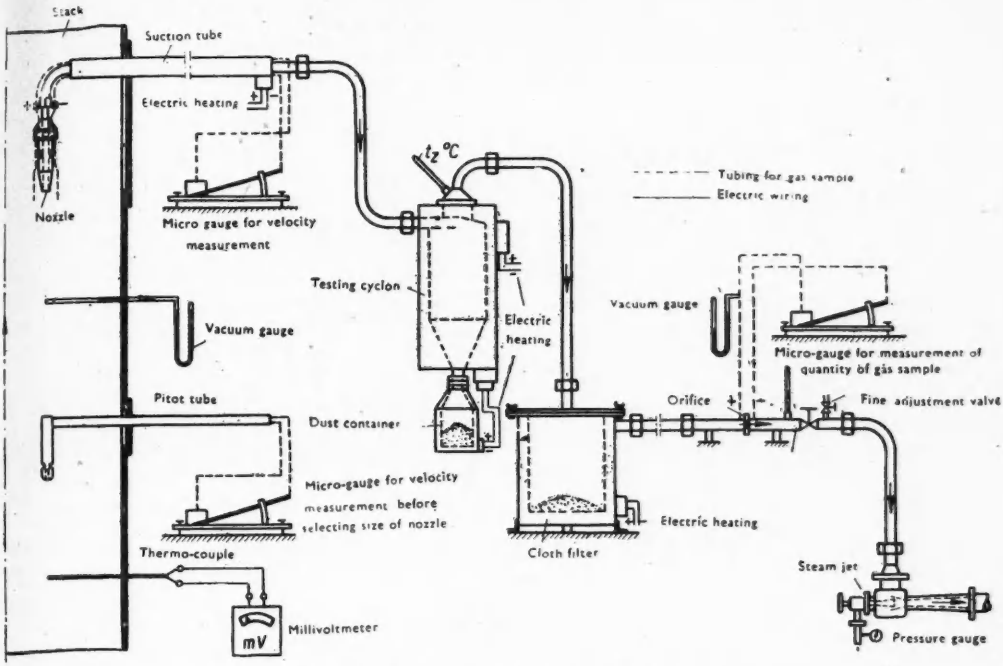


Fig. 10. Arrangement of the Babcock device.

nozzle required, the velocity of flow at the particular section should first be determined. Assuming, for instance, a temperature at the orifice of 175° F. and a mean pressure head of 1 in. w.g. then the gas flow through the orifice amounts to 1,850 cu. ft./hr. Since the differential pressure gauge reads up to 2 in. w.g. the range allows 1 in. variation of the mean pressure. The flow so determined is then to be converted to conditions corresponding to the nozzle section and by dividing it by the velocity, v, of flow the correct nozzle diameter can be found.

The advantages of large BEWAG apparatus are, of course, also inherent in the Babcock type, but the greatest accuracy obtained does not always compensate

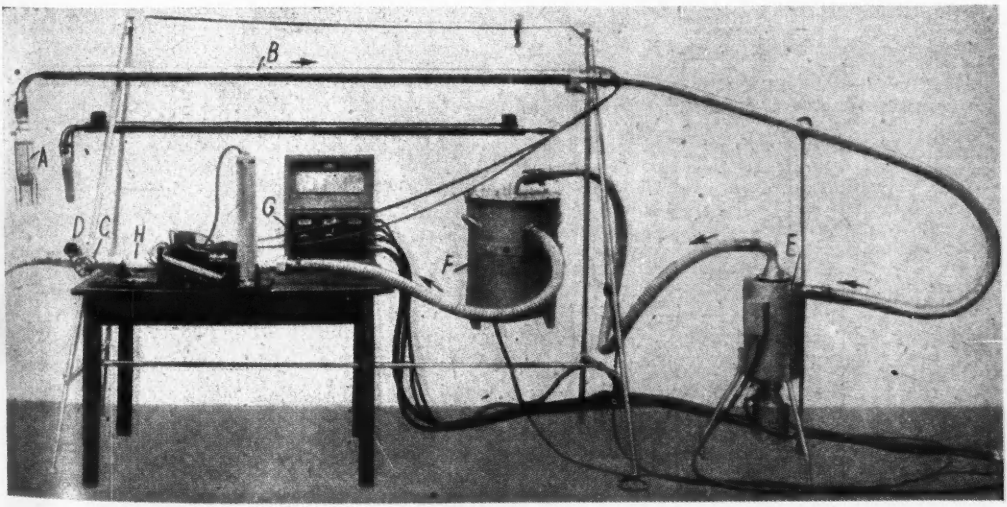


Fig. 11. Babcock device in use at the Halle Institute, for a capacity of 3500 cb. ft./hour.

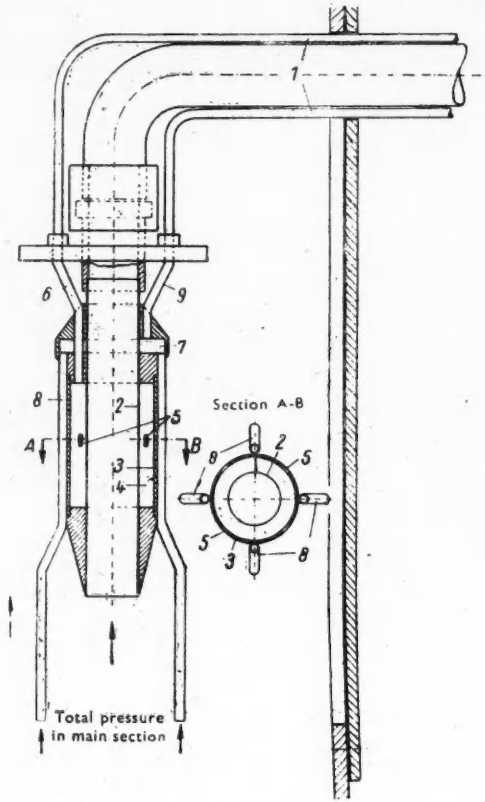


Fig. 12. Babcock nozzle for sampling and velocity measurement at the same time

for the inconvenience caused by additional size and weight of larger testing plants. As an example Table II. shows comparative results obtained with a large and a small testing apparatus. A fair conformity of results can be observed. The gas velocity was above 20 ft./sec. and the centrifugal dust separator was operated at about 68 per cent full load only.

TABLE II.

Description of device.	Nett dust content g/cu. ft.	Rate of dust precipitation %	Volume of gas sample.	
			cu.ft./hr.	% of the total gas.
Babcock's device of 3,500 cu.ft./hr. maximum capacity	0.715	57.6	2,145	0.19
BEWAG Rosenmuller device of 525 cu.ft./hr. maximum capacity	0.773	57.0	442.5	0.04

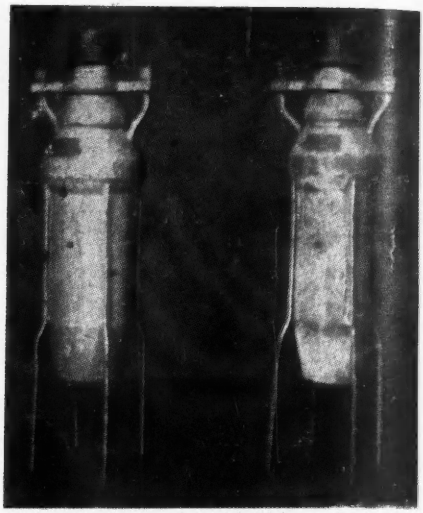


Fig. 13. Babcock nozzles with $2\frac{1}{8}$ in. and $2\frac{9}{16}$ in. diameter.

Method of Measurement in Circular Flue or Stack Sections

According to the "Approved Rules and Standards," the whole section must be divided into equal areas, and the sampling points be at their respective centre lines.

For circular section, the diameter d, of any concentric circle can be calculated from

$$d = D\sqrt{1 - \frac{2n-1}{z}}$$

where D is the internal diameter of circular flue or stack, d=diameter of circle, z=number of test points within

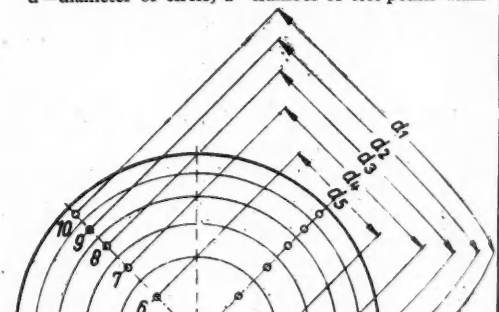


Fig. 14. Arrangement of 10 testing points in each of two diameters of a circular section.

the full diameter, z/2=number of equal areas. For points where n=notation of test point z/2, the values of d follow from symmetry.

No test point should be placed in the centre of the circle (see Fig. 14, drawn for 10 test points in each of two diameters).

As an example, for a stack of D=2.7 m. and z=10, the diameter of the largest circle, therefore n=1, is,

$$d = 2.7 \sqrt{1 - \frac{2.1 - 1}{10}} = 2{,}562 \text{ m.}$$

The distance (a) from the stack wall is :—

$$a = \frac{D - d}{2} = \frac{2.7 - 2.562}{2} = 0.07 \text{ m.}$$

Fig. 15 shows a graphical method, outlined by the Halle Institute, by which the diameter of the concentric circles can be easily plotted, for any number of test points. The figure demonstrates the values of d for 6 test points in a diameter of D = 1 m.

The author has described in this first paper details of the performance of tests to determine the dust content of flue gases. In a subsequent paper "The purpose of dust measurements," August 2nd and 9th, 1941, he explains the purpose of these tests which are :—

1. To supply the elements for the selection of the right sort of dust precipitator and for the specification of guarantees in enquiries or quotations.
2. Testing of the precipitator actually supplied.
3. Determination of the dust emission from the chimney of a boiler plant with regard to quantity and size.
4. Determination of the heat loss by unburnt fuel in the dust particles in order to divide up the heat losses balance sheet or for the indirect computation of the thermal efficiency when making boiler tests.

The author discusses problems which interest purchaser, contractor, or testing engineers when preparing the layout of new plant or testing existing boiler plants. He explains these requirements by two examples :—

(*a*) A new boiler plant with "Krämer-Mill" pulverised lignite firing, generating steam at the rate of 90,000 lbs./hr. at 1,840 lbs./sq. in. pressure has a chimney 475 ft. high which emits hourly between 450 and 860 lbs. of dust, representing a dust content of 1.1 to 2.25 g/cu.ft. respectively.

(*b*) An existing plant of 11 boilers of a total steam generation of 150,000 lbs./hr. burning waste from lignite, the flue gas of which is to be cleaned by a twin dust removing plant.

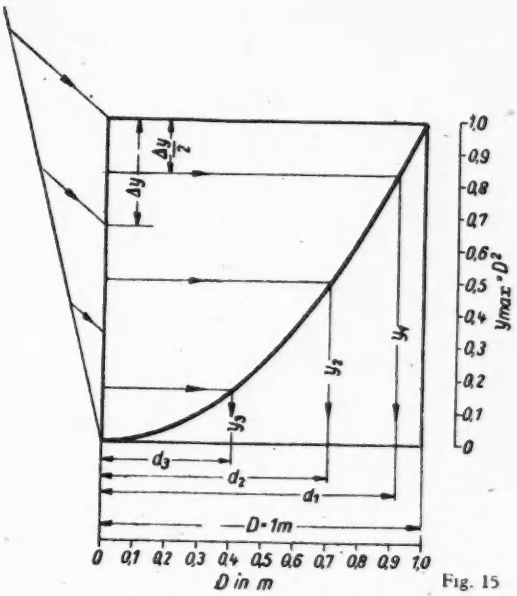


Fig. 15

Graphical method to determine the diameters of the circle of gravity referring to a stack of 1 m. diameter and 6 testing points.

The description of three different methods of determining the remaining dust content in the clean gases follows and a comparison between the degrees of dust precipitation as to dust size.

After these rather theoretical details, the author refers to the practical side of the test performance by giving different examples how to fit testing arrangements on chimneys or how to make tests just below the mouth of the stacks.

Finally, the author discusses questions of disturbances to the surroundings by the emission of dust from boiler house chimneys.

A NEW THREE-VOLTAGE DISTRIBUTION SYSTEM.

By C. Taubert, Berlin. (From *Elektrotechnische Zeitschrift* (ETZ), Vol. 63, No. 7/8, 28th February, 1942, pp. 85–88).

One of the following two systems is generally used for energy delivery to large urban supply areas, either the two-voltage system with low-voltage distribution transformers and big customers fed directly with the generating station bus voltage of 20 or 30 kV, or the three-voltage system comprising transmission with the generating station bus voltage to interposed sub-stations which transform from this voltage to a medium voltage of 3, 6 or 10 kV used for feeding the distribution low voltage transformers and big customers. Comparison of investment costs have shown, that generally the two-voltage system is superior to the three-voltage system, when applied in districts with heavy residential and commercial load, and only a small number of big customers. If, however, a great number of industrial and other big customers have to be supplied with the high tension of a two-voltage system, the high costs of the switch-plants and of the high rupturing capacity circuit breakers for 20 or 30 kV may render ineffective the economy attainable by the distribution with the generating station bus voltage, especially in the case of low consumption density. In industrial districts the three-voltage system has the further advantage, that no additional transformation has to be provided for the energy supply to high tension motors, which is necessary in the case of energy delivery with 20 or 30 kV.

In the three-voltage systems of the usual design each district of the medium voltage system is supplied by one sub-station, from which energy is distributed generally by loop feeders with 3 to 10 kV (Fig. 3, left figure). There arises then the serious disadvantage that, in the case of destruction or shut down of one sub-station the supply to the whole district concerned is interrupted. Emergency supply may be arranged, but generally only with great difficulty. In a two-voltage system the supply to a low tension distribution network can be provided from several distributing points, and in the case of a shut down of one such point, delivery may continue

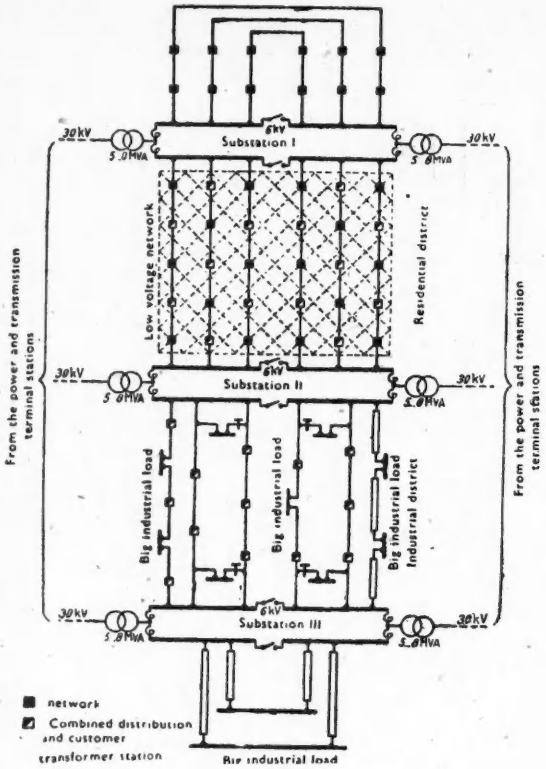


Fig. 1. Principle design of the new three-voltage system.

from another distributing point. The new three-voltage distribution system described in the following has many operating advantages in common with the two-voltage system.

Principle design of the new three-voltage system.

The principle feature of the new three-voltage system consists in a special manner of connecting the sub-stations through the medium voltage feeders (Fig. 1). There are two transformers in each sub-station connected to the two buses of the sub-station through reactors, as shown in the figure. Each bus is divided in two sections; by closing a tie breaker the two halves of a bus may be operated as one bus. However, these breakers are open during regular service in order to reduce the short-circuit currents. The sub-station busses are connected through the 6 kV feeders, which feed the low voltage distribution and consumer transformers. In order to reduce the short circuit currents all feeders, which originate from one sub-station bus section are connected at their other end to the same bus section of another sub-station. From this manner of connecting the feeders a medium voltage distribution system of loop form results, as can be seen in Fig. 1. Big industrial or other concentrated loads may be supplied by two feeders as shown in Fig. 1. The low tension distribution, which is fed by the distribution transformers, may be designed according to usual practice as a radial system or as a network.

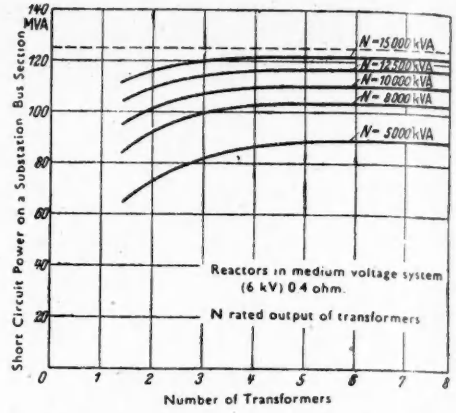


Fig. 2. Short-circuit power in a three-voltage distribution system of new design. High voltage 30 kV; medium voltage 6 kV.

Each sub-station transformer may be connected with two different generating plants or by an individual cable directly to a single power source. It depends on the design of the connections of the power sources, which kind of supply to the sub-stations will be preferred.

Important operating characteristics.

Short-circuit conditions.—By the grouping of the medium voltage feeders an effective limitation of the short-circuit currents is achieved. This result is considerably improved by the reactors common to all feeders which originate from one bus section as shown in Fig. 1. The effect of such reactors in a system according to Fig. 1 (30 kV high tension, 6 kV medium tension) is shown in Fig. 2. The short-circuit current in the medium voltage system approaches with increasing number of sub-stations a maximum value which is already nearly attained with four transformers. The effect of a higher rating of the transformers on the value of the short-circuit current is not considerable (Fig. 2). Therefore, medium voltage apparatus of the same moderate interrupting capacity may be used for the sub-stations, for the distribution transformers and for the switch-plants of high tension consumers.

Voltage regulation.—All feeders are supplied from both ends. This gives a good voltage regulation in the medium voltage system, in spite of the voltage drop in the reactors. Generally no voltage regulators are necessary in such systems, not even for the longest feeders.

Equalizing currents.—Differences between the voltages of feeding generating station busses produce equalising currents as an additional load of the medium voltage network and the sub-station transformers. In a system according to Fig. 1 a difference of 1 per cent between the voltages of two generating stations raises the load of the transformers by 2 to 5 per cent of their capacity. The higher value relates to transformers of 5,000 kVA, the lower value to transformers of more than 15,000 kVA. In order to reduce the voltage differences and the equalizing currents through the medium voltage system, the tie between the power sources has to be made as strong as possible. If each sub-station transformer is connected to the busses of two different power stations, an appropriate tie is achieved by these connections.

Spare units and service reliability.—When a transformer has to be disconnected in consequence of a fault

in the transformer or in its connection to the power source, its load is taken over proportionally by the two adjacent sub-stations. If the transformers carry normally 80 per cent of their rated output, they are loaded approximately up to normal overload capacity in such a case of emergency and there is no need to provide spare transformers in the sub-stations. That makes the design of the sub-stations with only two transformers very simple. The transformers have to be replaced by units of higher capacity, when the load of the sub-station exceeds their capacity.

The service reliability of this new system is greater than that of a three-voltage distribution system of the usual design. All low voltage distribution transformers and all high tension consumers are fed from two sub-stations. They do not depend on the service of one special sub-station.

Selective disconnection of any faulty part without disturbance of other parts of the system can be achieved by the use of relays of usual design. (The original publication contains two figures showing a protective system and discusses its functions in case of a short-circuit in a medium voltage feeder or on a sub-station bus.)

Application of the new three-voltage system.

The new system may be applied to energy delivery to urban areas of any size and of any kind and density of load. Investment costs for switching plants are lower than those for systems of the old design. The new system is most suitable for towns built according to the plans which are to be favoured in Germany in the future. Such towns are intended to consist of several long stretched parts, which are separated by tracts of parks and meadows. Each such part is intended to contain residential quarters as well as districts with industrial load. It seems very doubtful, if such urban areas comprising districts with low load density and districts with heavy power and commercial load may be supplied economically by a two-voltage distribution. In the three voltage systems as designed up to now with only a few rather large sub-stations the long feeders of the medium voltage system cause difficulties in long stretched areas in regard to voltage regulation and losses. These difficulties do not exist with the new system, which provides two or three smaller sub-stations in each district connected by the medium voltage feeders.

Comparison of investment costs of three-voltage systems of the old and the new design.

Investment costs have been calculated for a long stretched distribution system characterised by Fig. 3. The low voltage distribution may be assumed to be identical in an old and a new system three-voltage distribution. Therefore, the costs are the same in both cases. Different costs result for the 6 kV–network, the sub-stations, the 30 kV sub-transmission and the 30kV switch plants in the generating stations. It has been supposed that the 6 kV loop feeders have such cross sections, that they carry normally 50 per cent of their rated maximum load. The measured lengths of the feeders have been increased by 50 per cent for round abouts and for the connections to the sub-stations. The sub-stations of the old system are supposed to contain one spare transformer, those of the new system only two transformers. The 30 kV feeders are supposed to have a length of 6 km in both cases. The result of this comparative calculation is given in Table 1. Although the difference of the investment costs is not decisive, if the total costs of the plant are taken into consideration, the comparison shows, that the new design, when in competition with the old one, may be found advantageous also in economical respects.

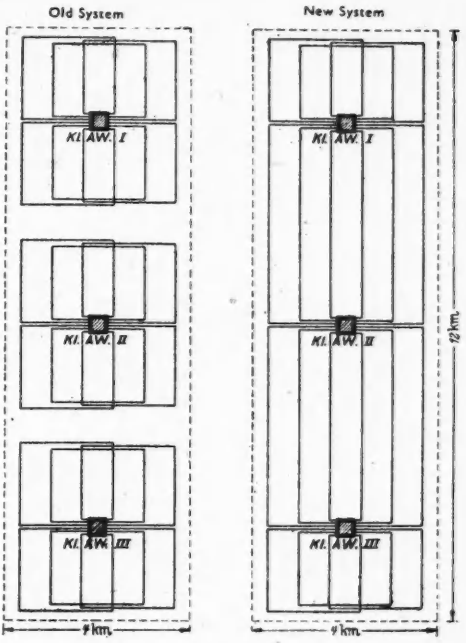


Fig. 3. Comparison of costs of three-voltage distribution systems of the old and the new design. High voltage 30 kV, medium voltage 6 kV.

TABLE 1.—COMPARISON OF INVESTMENT COSTS OF THREE-VOLTAGE DISTRIBUTIONS OF THE OLD AND THE NEW DESIGN.

Distribution System.		Old.		New.	
Mean Load Density kVA/km.²		500	1,000	500	1,000
Costs which depend on the system RM/kVA in relation to the load in the power station.	6 kV system	66.80	58.70	72.40	53.90
	Substations	67.30	46.40	54.30	40.60
	30 kV system	43.90	32.90	43.90	24.60
	Power station switch plant	14.60	11.00	14.60	7.30
	Total	192.60	149.00	185.20	126.40

DISTILLED WATER

. . . has hitherto only been obtainable by "Distillation." It is possible to-day by The **Permutit** Company's new and exclusive **"Deminrolit"** process to obtain large quantities of its equivalent cheaply and simply. This revolutionary process has already found its place in World Industry and plants are in operation for varied uses including Boiler Feed. It is fully described in our Booklet :—

DISTILLED WATER WITHOUT DISTILLATION

Write for a copy to—The **PERMUTIT** Company Limited, Dept. T.B., Permutit House, London, W.4.

Telephone : CHIswick 6431 Cables : Permutit, Londor

TECHNICAL NEWS

Announcements in this section include News relating to British Firms, and on Equipment produced by British Manufacturers.

Available literature may be secured by addressing a request to the advertising department of "The Engineers' Digest," or by writing direct to the manufacturer and mentioning "The Engineers' Digest" as a source.

- NEW EQUIPMENT
- BOOKS AND CATALOGUES
- BUSINESS CHANGES
- PERSONAL
- NOTES

NEW EQUIPMENT

COOKE OPTICAL DIVIDING HEAD.

A pamphlet describing the Cooke Optical Dividing Head, has been issued by Cooke, Troughton and Simms Ltd., Kingsway North, York. The instrument incorporates the following features.

The graduated circle is mounted co-axially with the main spindle and its movement is observed with a micrometer microscope, thus errors which commonly occur with the mechanical head are eliminated. The graduations are marked on a glass annulus which is mounted on the spindle, the greatest care being taken in centring the circle. The circle, being completely enclosed, is protected from floating dust, dirt or oil, and, since its only contact with the instrument is the spindle upon which it is mounted, it is not subject to wear.

The body of the microscope is housed within the instrument and is similarly protected from wear or damage. The circle dividing and figuring is to one degree and the intervals are taken from an optical micrometer calibrated to read directly to one minute. The employment of an optical micrometer in contrast to a scale fixed at the focal plane of the eye-piece results in an open scale which allows accurate interpolation to ten seconds or less.

The illuminating system is housed within the instrument and is designed to avoid heating it to an extent which would impair the accuracy of measurement. The current for the lamp may be provided from alternating mains through a small transformer.

The dividing head is mounted in a cradle in order that the measuring spindle may be capable of adjustment through 90° in the vertical plane. An exterior scale and vernier reading to 6 min. is provided to facilitate this. Horizontal and vertical positions are precisely defined by adjustable stops with hardened faces.

The spindle is carried in massive bearings, that nearest to the work being tapered, whilst the other is parallel. The spindle is bored to take a No. 4 Morse taper.

The worm and worm-wheel motion is provided for setting the spindle and this may be rapidly disengaged to facilitate setting to the approximate position required. (Note : the worm gear in the present instrument has no function of measurement and is solely for rotating the spindle).

The inherent accuracy of the instrument, that is, when it is used for measuring and is unaffected by exterior conditions, is of the order of 10 seconds of arc. When used for machining purposes this obviously depends upon the manner in which the machine is used. If used for the lightest finishing cuts, as should always be the case, results may be obtained to within 20 seconds.

LONDEX WELDER TIMERS.

LONDEX Welder Timers consist of one or more adjustable time circuits controlling an output relay of suitable switching capacity to control the welding contactor. The complete units are mounted in sheet iron casings suitable for wall mounting. The time circuits are purely electrical and do not depend on clockwork valves or electric motors. They are simple, robust and reliable. The actual time ranges covered can be altered considerably to suit any particular application. As an example the type "C" Timer has a three-position switch giving either spot, seam or non-automatic welding. Three adjustable dials control the welding time and the interval between welds for seam working and the welding time for spot working respectively. Variation of setting on all three controls is continuous over the whole range and is not carried out in steps. Normal time ranges are approximately 1/10th to 1 second weld time with similar intervals between welds for seam working, and approximately 1/10th to 3½ seconds for spot welding. A useful feature fitted as standard is a "test weld" switch which, when placed in the "test" position, enables the operator to observe the setting chosen by watching the indicating lamp built into the instrument before actually carrying out a weld. Multi-range Welder Timers can be made up where the normal range is insufficient to cover all the requirements. These Welder Timers are manufactured by Messrs. Londex Ltd., of 207, Anerley Road, London, S.E.20.

Londex Welder Timer Type C.

CATALOGUES RECEIVED

Neillarc Portable Electric Welding Plant.—Wm. Neill & Son (St. Helens) Ltd., Bold Iron Works, St. Helens Junction, Lancashire, have issued a 12-page brochure with the intention to give general information on the structure and use of the "Neillarc Portable Electric Welding Plant."- The machine was originally designed for use in the erection department of the firm, and it has been tested under the most trying climatic conditions. As a result the unit, it is claimed, will stand up to really hard work. The standard unit is

driven by a four-cylinder side valve petrol engine, developing 43 h.p. at 1440 r.p.m. The controls are very simple to operate. The fuel tank has a capacity of 36 gallons. Forced water circulation and a fan are provided for cooling. As the units may be called upon to operate in a dusty atmosphere, an air filter, easily accessible for cleaning purposes, is fitted on the carburetter intake of each engine. A control panel on the generator allows the operator to adjust the welding current quickly and easily over a wide range. Free copy of the brochure may be secured on application.

Bastian & Allen, Ltd., 24, Bedford Square, London, W.C.1, have issued a 4-page leaflet which gives a brief survey of the installations and the widely differing applications of their heating equipments. This firm has been responsible for many important developments in electrical heating. The range of the firm's production programme includes the manufacture of Electrode Boilers, Immersion Heater Boilers, Heating Plants for all industrial processes, Electrically-driven Automatic Coal Burners, etc. Copy of the leaflet can be obtained free upon request.

The Universal Slotmaster, manufactured by the Experimental Tool and Die Co., Detroit, Mich., is described in a leaflet published by the British Representatives of this firm the Broadway Engineering Co. Ltd., Carlisle Road, Hendon, London, N.W.9. A slotting head that can be used on all milling machines provides double duty facilities at a minimum of cost. It requires but little time to change over from one head to the other and back again. The Slotmaster can be used for cutting key-ways, templates, splines, internal gears, and for slotting out precision blanking dies, or wherever sharp corners and special shapes are machined.

Bath Universal Grinder.—A 12-page brochure just issued by the Broadway Engineering Co. Ltd., Carlisle Road, Hendon, London, N.W.9, contains a number of illustrations and detailed description of the latest design grinding machine of the Fitchburg Grinding Machine Co. The attachments required for special grinding operations as well as those for cutter grinding, surface grinding, and internal grinding, are included in the illustrations. Free copy of the brochure may be obtained upon application.

The British Institution of Radio Engineers (Duke St. House, Duke Street, London, W.1).—The Institution's Programme Committee have now completed arrangements for the whole of the London Section Programme Meetings from September, 1942, to May, 1943, inclusive. The first two meetings, in London, are :—
Paper on "Modulation," by J. Robinson, D.Sc., M.I.E.E.—Sept. 26th. Paper by L. H. Bedford, M.A., on "Time Units"—Oct. 23rd.

BUSINESS CHANGES

F. Corlett & Co. Ltd., General Engineers and Sheet Metal Workers, are taking up more extensive premises at Parkside Mill, Royton, near Oldham.

Clare-Collets Ltd., Manufacturers of the Clare Patent Drilling and Milling Chucks, have moved in new more modern and larger premises at Salford. The present address is Clare-Collets Ltd., Springfield Lane, Salford 3, Lancs.

Butterfields Ltd., Manufacturers of the HEC Air Compressors and the Levis Motor Cycles, Stechford, Birmingham 9, have changed the name of the firm as from the 18th August to Levis Ltd.

HEAT TREATMENT SPECIALISTS

ON APPROVED LIST OF AIR MINISTRY AND ADMIRALTY

- Case Hardening and straightening up to 8 ft. long.
- Hardening all Classes of High Speed Steel Tools, Bakelite Moulds and Press Tools.
- Cyanide Hardening. Capacity 3 tons per week.
- Springs : Any size, shape or quantity.
- Aluminium Alloys Heat Treated to A.I.D. Specifications.
- Heat Treatment of Alloy Steels up to 10 ft. long.
- Heat Treatment of Meehanite Castings, etc.
- Crack detecting on production lines.

THE EXPERT TOOL & CASE HARDENING CO. LTD.
(Est. 1918)
Phone LIBERTY 2273-4
MORDEN FACTORY ESTATE : LONDON : S.W.19
And GARTH ROAD, LOWER MORDEN, SURREY.
Telephone : Derwent 3122

STAFFA
MACHINE TOOLS AND PRODUCTS

★ HYDRAULIC TUBE & BAR BENDERS ★
★ HEAVY DUTY GRINDERS ★
★ HAND FLY PRESSES ★
★ COMBING CUTTERS ★

Full particulars from
Commercial Structures ENGINEERS LTD.
STAFFA ROAD :: LEYTON, E.10